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Permit Writers' Guidance Manual for Hazardous Waste Land Storage and Disposal Facilities Phase 1. Criteria for Location Acceptability and Existing Applicable Regulations

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The 'Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage, and Disposal Facilities' has three purposes: (1) to provide guidance in defining acceptable physical locations for hazardous waste land treatment, storage, and disposal (HWLTSD) units, (2) to cite available regulations and statutes and how these should be applied in evaluating the acceptability of locations, and (3) to present an outline summary of future Agency efforts to ensure both proper site analysis and safe location of such facilities. The intended audience is EPA Regional Office staff and authorized State Agency personnel who evaluate permit applications under the authority of the Resource Conservation and Recovery Act (RCRA). Part of a broad program to encourage safe and proper siting of hazardous waste facilities, this manual is the first of a five document series.

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Permit Writers' Guidance Manual for Hazardous Waste Land Storage and Disposal Facilities

Phase I

Criteria for Location Acceptability and Existing Applicable Regulations

Final Draft

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PERMIT WRITERS' GUIDANCE MANUAL FOR THE LOCATION OF HAZARDOUS WASTE LAND TREATMENT, STORAGE, AND DISPOSAL FACILITIES

PHASE I

CRITERIA FOR LOCATION ACCEPTABILITY AND EXISTING REGULATIONS FOR EVALUATING LOCATIONS

FINAL DRAFT

Office of Solid Waste
Waste Management and Economics Division
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

FEBRUARY 1985

DISCLAIMER

This report has not been formally reviewed by the U.S. Environmental Protection Agency (EPA), and it is not approved as an official Agency publication. The contents do not necessarily reflect the views and policies of the EPA.

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Consultants played major roles in the preparation of the guidance manual. Dr. William Doucette of Radian Corporation developed the major technical sections of the manual and provided technical assistance and background information in formulating the manual. Dr. Keros Cartwright of the Illinois Geological Survey provided thoughtful comment on the approach to location evaluation. Diane Heineman of GCA Corporation--Technology Division compiled peer-review comments on the draft version of the manual and provided technical support. Background information on weak and unstable soils was assembled by J.B. McCutchan and K.T. Ajmera of Radian Corporation.

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EXECUTIVE SUMMARY

The "Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage, and Disposal Facilities" has three purposes: (1) to provide guidance in defining acceptable physical locations for hazardous waste land treatment, storage, and disposal (HWLTSD) units, (2) to cite available regulations and statutes and how these should be applied in evaluating the acceptability of locations, and (3) to present an outline summary of future Agency efforts to ensure both proper site analysis and safe location of such facilities. The intended audience is EPA Regional Office staff and authorized State Agency personnel who evaluate permit applications under the authority of the Resource Conservation and Recovery Act (RCRA).

This Phase I manual provides guidance concerning the physical location of hazardous waste treatment, storage, and disposal surface impoundments, waste piles, and landfills. Location guidance for land treatment units will be provided in a future document. Part of a broad program to encourage safe and proper siting of hazardous waste facilities, this manual is the first of a five document series. Other documents include:

a. a review of State siting criteria for hazardous waste treatment, storage, and disposal facilities,

b. a Phase II document describing technical methods for evaluating locations and for determining a vulnerable hydrogeology,

c. appendices to the Phase II document containing case studies and technical resource documents, and

d. a permit writers' guidance manual for the location of land treatment units.

Section 2.0 of this guidance manual describes five criteria for determining location acceptability. The five criteria are:

a. Site Characterization - The inherent geologic, hydrologic, and pedologic features of the site can be fully characterized.

b. High Hazard and Unstable Terrains - The site provides a stable foundation for the engineered containment structure, is not subject to likely events, either natural or man-induced, that would damage engineered containment structures, and does not require active, ongoing maintenance of engineered containment structures due to instability or high hazard and unstable terrain conditions following closure. Sensitive areas that should be evaluated against this criterion are:

   ° flood-prone areas,
   ° seismic impact zones,
   ° volcanic impact zones,
   ° landslide-susceptible areas,
   ° subsidence-prone areas, and
   ° weak and unstable soils.

c. Ability to Monitor at Location - All potential groundwater flow paths can be monitored or the facility is located in a minimal recharge zone.

d. Protected Lands - The facility complies with statutes and rules for Federally-protected lands. Protected lands include:

   ° archaeological and historic places,
   ° endangered and threatened species and critical habitat,
   ° parks, monuments, and scenic rivers,
   ° wilderness areas,
   ° coastal areas,
   ° wildlife refuges,
   ° significant agricultural lands, and
   ° wetlands.

e. Vulnerable Hydrogeology - The facility is not in a vulnerable setting above Class II ground water as defined in the Agency's Ground-Water Protection Strategy.

Currently, 40 CFR Part 264 permit standards specify design and operating requirements for hazardous waste facilities and establish ground-water monitoring and corrective action requirements. While Part 264 does not contain explicit location standards based on hydrogeologic considerations, the ground-water monitoring and corrective action regulations and the design and operating requirements contain performance standards that implicitly involve hydrologic and geologic factors. Current regulations do not provide the legal basis to deny a RCRA permit at some sensitive locations. For example, there is no legal basis for permit denial at a location that satisfies all criteria except the ground-water vulnerability criterion. Section 3.0 presents existing regulations that permit writers should apply when evaluating permit applications against location issues. These regulations may provide a basis for conditioning or denying permits to owners or operators for facilities at certain locations that do not satisfy one or more of the first four criteria cited above. Except with respect to the vulnerable hydrogeology criteria (to be developed in a Phase II manual), this manual describes a number of locations that are particularly sensitive areas where the criteria for location acceptability are less likely to be met. At these locations, permit writers must examine whether a facility can be designed, constructed, operated, and maintained to comply with existing regulations. Table ES-1 provides a matrix of existing RCRA regulations related to the first four criteria for location acceptability that must be evaluated in these sensitive locations.

The Agency's current regulations do not provide a clear basis for denying all permits to owners or operators of facilities that are located in settings where hydrogeologic conditions make ground water beneath the site especially vulnerable to contamination. The Agency's Ground-Water Protection Strategy, however, presents a framework for implementing a number of regulatory decisions that are related to ground-water quality issues. The Strategy guides decision-making under existing regulations, and indicates where regulations will be amended or created in order to fully implement the policies. Of particular importance to the RCRA program is the classification of ground water into three classes and the accompanying division of certain classes into vulnerable and non-vulnerable hydrogeologic settings. In addition, recent statutory amendments under RCRA require that certain facility design and operation provisions are based on whether the facility is in an area that may be considered a vulnerable hydrogeology.

The Phase II guidance manual will present a definition of a vulnerable hydrogeology and analytical methods for use in applying the definition to individual facilities. This definition and the accompanying methods are being developed in cooperation with the EPA Office of Ground-Water Protection (OGWP) which is characterizing vulnerability within a larger context. Additional guidance on the definition of the three ground-water classes will be provided by the OGWP at the same time. The Agency will then develop amendments to the RCRA Part 264 ground-water protection standards to provide a regulatory basis for applying vulnerable hydrogeology criteria in permitting RCRA hazardous waste facilities.

Other regulatory amendments will also be made to fully implement the other provisions of the Ground-Water Protection Strategy. This Phase I guidance manual discusses a vulnerable hydrogeology only to the extent necessary to illustrate how the concept will be ultimately applied after the appropriate amendments are made to the permitting standards.

All applications for Part 264 permits must be evaluated against certain existing performance standards and application information requirements that implicitly involve facility location issues. Permit writers may determine after analysis that the applicant has not demonstrated that the facility will satisfy one or more of the following:

a. monitoring requirements (Part 264.92 and 264.97)

b. liner foundation requirements (Parts 264.221(a), 264.251(a), and 264.301(a)),

c. the closure standards (Parts 264.111, 264.228(a), and 264.310(a)),

d. dike integrity requirement (Part 264.221(d)).

An inability to satisfy these standards is grounds for permit denial.

Location factors may also be relevant to other decisions made under the Part 264 permitting program. In certain cases, supplemental provisions under Part 264 can be used to modify a permit based on certain location concerns. Decisions regarding these supplemental provisions are discussed in various sections of this guidance manual and referenced in Table ES-2. These may include the following decisions:

a. whether to grant Alternate Concentration Limits (ACLs) in the facility's ground-water protection standard or to exclude Appendix VIII constituents from monitoring under Section 264.93,

b. whether to require a contingent corrective action program, and

c. extending the post-closure period.

In addition, the permit writer may have grounds for permit denial if the applicant is not in compliance with certain other Federal Statutes designed to protect scenic rivers, wetlands, archaeological sites, and other Federally-protected resources. Table ES-3 provides a summary of applicable Federal statutes and rules that form the basis of the fourth criterion for location acceptability. Under Part 270.14(b)(20), the permit applicant may be required to submit additional documentation to show that the location at which his or her facility is sited is in compliance with other "protected" land statutes. Section 2.0 of this manual provides permit writers with guidance in determining whether a RCRA permit application is consistent with these other applicable Federal Statutes. Permit writers should more routinely seek to coordinate with the appropriate Federal Agency for assistance in determining facility compliance with other Federal statutes.

The Imminent Hazard Provision under Section 7003 of RCRA gives the Agency broad authority to issue administrative orders where the presence of solid waste or hazardous waste may present an imminent and substantial endangerment to health or the environment. Section 3.4 of this Manual presents guidance on the applicability of Section 7003 Administrative Orders that supplements existing Agency guidance.

Section 4.0 provides the permit writer with site case study summaries based on actual RCRA permit applications submitted to various EPA Regional Offices. The case studies are used to illustrate how the location criteria presented in this manual should be applied when evaluating RCRA permit applications. Recommended responses that the permit writer should make regarding various locational issues are also included. These summaries and additional case studies currently being evaluated will be presented in more detail in Case Study Appendix E to the Phase II permit writers' guidance manual.

Section 5.0 of this manual outlines the current Agency program for developing and implementing RCRA location guidance and regulations under 40 CFR Part 264. A brief description of subsequent guidance materials is presented.

The Phase I Location Guidance Manual was developed prior to the passage of the Hazardous and Solid Waste Amendments (HSWA) of 1984 and is not the "location guidance" called for by the amendments. That location guidance (Phase II) will be forthcoming and will be clearly identified as guidance that fulfills the requirements of the RCRA amendments.

TABLE ES-1: CROSS-REFERENCE OF ACCEPTABLE LOCATION CRITERIA AND EXISTING RCRA STANDARDS FOR EVALUATING LOCATIONS

CRITERIA FOR LOCATION ACCEPTABILITY	RCRA Part 264 Standards						
	General Part B Requirements	Seismic Standard	Floodplain Standard	Monitoring Requirements	Liner Foundation	Closure Standard	Dike Integrity
Manual Section	2.1	3.1	3.1	3.2.1	3.2.2	3.2.3	3.2.4
Site Characterization	S,D	S,D	S,D	S,D	S,D	S,D	S,D
High Hazard and Unstable Terrain							
a. Flood-prone areas			S,D				
b. Seismic impact zones		S,D			S,D	D	S,D
c. Volcanic impact zones					S,D	D	S,D
d. Landslide-susceptible areas					S,D	D	S,D
e. Subsidence-prone areas		S,D		S,D	S,D	D	S,D
f. Weak and unstable soils					S,D	D	S,D
Ability to Monitor				S,D			
Groundwater Vulnerability			(No regulatory basis at present to deny permit)				

APPLICABLE FACILITY TYPES
S = Storage Unit
D = Disposal Unit

TABLE ES-2: SUPPLEMENTAL RCRA PROVISIONS USEFUL AS A BASIS FOR PERMITTING

CRITERIA FOR LOCATION ACCEPTABILITY	ACL/Appendix VIII Restrictions	Contingent Corrective Action	Exclusion of App. VIII Constituents	Extended Post-Closure Care Period	
Manual Section	3.3.1	3.3.2	3.3.3	3.3.4	Comments
Site Characterization					Supplemental RCRA provisions listed are found in the following sections of 40 CFR Part 264, respectively:
High Hazard and Unstable Terrains					
a. Flood-prone areas	D			D	
b. Seismic impact zones					§264.94(b) and (c) §264.91(b) §264.93(b) §264.117(a)(2)(ii)
c. Volcanic impact zones		S,D		D	
d. Landslide-susceptible areas		S,D		D	
e. Subsidence-prone areas		S,D		D	
f. Weak and unstable soils		S,D		D	
Ability to Monitor	D	S,D	S,D	D	

APPLICABLE FACILITY TYPES
S = Storage Unit
D = Disposal Unit

TABLE ES-3: PROTECTED LAND STATUTES AND REGULATIONS

CRITERIA FOR LOCATIONAL ACCEPTABILITY	STATUTES/REGULATIONS
PROTECTED LANDS:	
- ARCHAEOLOGICAL/HISTORIC PLACES	National Historic Preservation Act (NHPA) of 1966; 16 U.S.C. §§ 470 et seq.
- ENDANGERED/THREATENED SPECIES	Endangered Species Act of 1973; 16 U.S.C. §§1531-1543
- PARKS, MONUMENTS, AND RIVERS	Wild and Scenic Rivers Act; 16 U.S.C. §§ 1273 et seq.
- WILDERNESS AREAS	Wilderness Protection Act of 1964; 16 U.S.C. §§1131-1136
- COASTAL AREAS	Coastal Zone Management Act; 16 U.S.C. §§1451 et seq.
- WILDLIFE REFUGES	50 CFR Part 27.94
- SIGNIFICANT AGRICULTURAL LANDS	7 CFR Part 658
- WETLANDS	Section 404 of the Clean Water Act (CWA) of 1977; Presidential Executive Order 11990

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1.0 INTRODUCTION

The physical location of HWLTSD facilities directly influences the potential for impacting human health and the environment. Physical location refers to the geologic, hydrologic, and pedologic characteristics of a site as well as adjoining lands, surface water, and ground water that may be impacted in the event hazardous constituents are released from the facility. A 1983 EPA study (Liner/Location Study by Ertec Atlantic, Inc.) concluded that proper site selection and appropriate hydrologic and geologic conditions are important factors in maintaining long-term protection of the environment. In addition, the RCRA reauthorization contains specific amendments that require the Agency to promulgate location regulations and to provide location guidance concerning the potential vulnerability of ground-water to contamination based on hydrogeologic conditions at a site. This Phase I Guidance Manual was developed prior to the passage of the RCRA amendments and is not the "location guidance" called for by the amendments. That location guidance (Phase II) will be forthcoming and will be clearly identified as guidance that fulfills the requirements of the RCRA amendments. The Agency's Ground Water Protection Strategy recognizes the importance of hydrogeologic factors in protecting public health and the environment from contamination related to a number of waste disposal and product utilization practices. This Strategy establishes a framework for decision-making under several Agency programs, and outlines areas for future rulemaking or amendments to existing regulations. The Phase II RCRA Permit Writers' Guidance Manual will incorporate the Strategy and will reference accompanying guidance on classification of ground water.

On December 18, 1978, EPA proposed standards to control the location of facilities in seismic zones, 100-year floodplains, coastal high hazard areas, 500-year floodplains, wetlands, critical habitats of endangered and threatened species, and recharge zones of sole source aquifers, as well as specific standards to delimit the location of active portions of facilities with respect to the facility's property line. Public comments and additional research regarding the proposed standards were evaluated and on January 12, 1981, EPA promulgated two of the eight candidate standards: the 100-year floodplain and seismic zone restrictions. The other six standards were not promulgated because they either required more research, were at least partially addressed in regulations promulgated under laws other than RCRA, or were rejected as unnecessary to protect human health and the environment, e.g., the 500-year floodplain restriction. Revisions to the floodplain standard were published in the Federal Register on July 26, 1982.

Based upon a recent review of selected RCRA permit applications, the Agency has found that many HWLTSD facilities are located in terrains that may cause adverse impacts to public health and the environment and that the safe and proper location of such facilities has not been a priority in the past.

1.1 SCOPE OF DOCUMENT

The scope of this guidance document covers the physical location of landfills, waste piles, and treatment, storage, and disposal surface impoundments. Although limited information related to land treatment units is provided, a seperate manual entitled, "Permit Writers' Guidance Manual for the Location of Land Treatment Units," is being prepared and should be available during the latter part of 1985.

Land treatment units are subject to many of the same location concerns as are storage and disposal facilities; however, land treatment facilities are functionally different from storage and disposal facilities and require a somewhat different approach in defining location acceptability. While storage and disposal facilities serve as a means of containment for hazardous constituents, land treatment facilities are sited and operated to degrade, transform, or immobilize hazardous constituents. Locational concerns related to land treatment will be pointed out as appropriate in the text.

Only those parameters important to physical location are addressed in this guidance manual; engineered features such as liners are not considered. By separating the engineered features of the hazardous waste land storage and disposal unit from physical location factors of a site, it should not be inferred that the Agency considers engineered elements of a unit to be unimportant. The design of liners, caps, and other features of HWLTSD units is of utmost importance in minimizing the potential for hazardous waste contaminant generation and release. In order to evaluate locational acceptability, it is important to consider separately the physical elements that are intrinsic to the natural terrain of a sensitive site. However, in determining whether a location is acceptable or unacceptable for siting, a permit writer should first evaluate whether a facility can be designed to withstand physical events and conditions that exist or that are likely to occur at the location. If a facility cannot be designed to withstand such events or conditions, the permit writer must also evaluate the ability of the location to minimize the potential for exposure of the public and environment to the waste in the event that the engineered containment structures (liner and cover) fail.

1.2 RELATED LOCATION GUIDANCE DOCUMENTS

This guidance manual is the first phase of a broad EPA program to establish guidance and standards under RCRA for the location of hazardous waste land treatment, storage, and disposal facilities. Conducted by the Office of Solid Waste, the program is designed to encourage the safe and proper siting of facilities. This manual is one of a series of five guidance documents. The four other documents are listed below as follows:

a. Review of State Siting Criteria for Hazardous Waste Treatment, Storage, and Disposal

b. Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage, and Disposal Facilities. Phase II: Criteria for Evaluating a Vulnerable Hydrogeology

c. Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Storage and Disposal Facilities. Phase II: Location Analysis Methods, RCRA Case Studies, and accompanying technical Appendices A through E

d. Permit Writers' Guidance Manual for the Location of Land Treatment Units

2.0 CRITERIA FOR AN ACCEPTABLE LOCATION

The human health and environmental impacts that may occur when a hazardous waste land treatment, storage, or disposal (HWLTSD) facility fails differ dramatically depending upon the facility's physical location. Analysis of the first submissions of RCRA Part B permit applications indicates that in the event of design and operating control failure, many new as well as existing HWLTSD facilities are sited in locations having hydrogeologic characteristics that favor rapid release of waste constituents and maximize the potential for adverse impact. Permit writers should evaluate both new and existing HWLTSD facility locations based on the ability of hydrogeologic conditions to encourage waste containment, reduce contaminant migration, and minimize adverse impact.

The Agency has established five criteria for evaluating an acceptable location. These criteria are based on experience with remedial actions at uncontrolled waste sites and investigations of various locations of existing RCRA facilities. The term "location" as used in this manual encompasses the specific hydrologic, geologic, and pedologic characteristics of the facility site and related features of the surrounding terrain.

Criteria for an acceptable location are as follows:

a. Site Characterization - The inherent geologic, hydrologic, and pedologic features of the site and location at large can be fully characterized. Complete characterization means that a permit applicant must be able to delineate the ground-water flow path for constituents that may be released from a unit, determine ground-water flow velocity along the flow path, and determine subsurface geotechnical properties necessary to design the unit liner, cover, and impoundment dikes. Permit applicants seeking Alternate Concentration Limits (ACLs) and approval of corrective action programs must also provide additional data regarding contaminant transport and behavior in the ground-water system assuming hazardous constituents are released from the engineered containment structure.

b. High Hazard and Unstable Terrains - The site geology can provide a stable foundation for the engineered containment structure and is not subject to likely events, either natural or man-induced that would impair the containment structure. The site geology is such that active ongoing maintenance of engineered containment measures following unit closure is not required. High hazard and unstable terrains include those locations that are prohibited by existing location standards (i.e., 100-year floodplain and seismic standards) and those locations that are highly susceptible to events and conditions that exist or are likely to occur at a site that could severely damage containment structures and for which protective measures cannot be designed, such as seismism, faulting, volcanism, landslides, and land subsidence.

c. Ability to Monitor - All potential ground-water flow paths in the uppermost aquifer along which constituents can migrate from the regulated unit can be characterized and ground-water quality can be monitored. In addition, it must be possible to install monitoring wells to collect samples of ground water unaffected by leakage from a regulated unit (i.e., background wells), except in areas where sources of moisture for ground-water recharge are negligible. A exemption from ground-water quality monitoring may apply where a unit is located in a minimal recharge zone. This exemption does not generally apply to surface impoundments and other facilities that store or dispose of liquid waste since the presence of these liquids may be a significant component of recharge to ground water. A minimal recharge zone is an arid terrain characterized by negligible sources of moisture available to recharge ground water. The feasibility of the permit writer granting an exemption in such a location should be based upon a case-by-case determination.

d. Protected Lands - The facility complies with statutes and standards applicable to Federally protected land resource values. Protected lands include:

1. archaeological and historic places,
2. endangered and threatened species habitat,
3. parks, monuments, and scenic rivers,
4. wilderness areas,
5. coastal areas,
6. wildlife refuges,
7. significant agricultural lands, and
8. wetlands.

e. Vulnerable Hydrogeology - The facility is not within a vulnerable setting above Class II ground water as described in the Agency's Ground-Water Protection Strategy or as may be defined directly in the RCRA amendments of 1984. (The definition of a vulnerable hydrogeology will be described in the Phase II Permit Writers' Guidance Manual for Location of HWLTSD Facilities).

Locations that do not satisfy all of the above criteria are considered "unacceptable" and the permit writer should consider either modifying the permit or permit denial. Current regulations, however, do not provide the legal basis to deny a RCRA permit at some sensitive locations. For example, there is no legal basis for facility permit denial at a site that satisfies all location criteria except the vulnerable hydrogeology criteria. However, several existing regulations may serve as a basis for facility permit conditioning or denial at locations that do not meet the requirements of the first four criteria (see Section 3.0 of this manual). When a facility is sited in a sensitive location but a permit cannot be denied using existing regulations, other protective measures can be taken (see Section 3.3 of this manual). New regulations that directly address the subject of vulnerable hydrogeology and other conditions and events discussed in this manual that are not addressed by existing regulations, will be developed to supplement current RCRA standards. Until these regulations are promulgated, siting at sensitive locations that fail any of the above criteria but for which existing regulations will not provide the basis for modifying or denying the facility permit, should be discouraged.

Permit writers should also inform applicants that expansions of existing facilities in these sensitive locations may possibly be denied on the basis of future regulations. In evaluating locations against the criteria defined in this guidance manual, it is important that the permit writer does not overstate the policies reflected in this document. The five criteria for location acceptability establish a general set of considerations relevant to permit issuance that the permit writer should use in deciding whether the owner or operator is in compliance with all relevant existing regulations and statutes. It would be a misuse of this guidance to conclude that each sensitive location described in this manual is necessarily an unacceptable location for which a facility permit should be denied. Rather, the permit writer should use this manual to assist in evaluating sensitive locations where the facility design, construction, operation, maintenance, and ground-water monitoring program must be carefully examined. The determination of whether the facility location is unacceptable and a permit should be modified or denied depends ultimately on the ability of the owner or operator to comply with all relevant existing regulations and statutes cited in this manual.

The following discussion of each location criterion specifies the existing RCRA regulations and other Federal statutes that permit writers should apply when evaluating location, and provides recommendations for dealing with locations that fail any of the location acceptability criteria. Location case studies based on information submitted in RCRA facility permit applications are summarized in this manual. These case studies illustrate how the location criteria and related existing regulation and statutes should be applied. The reader is referred to Section 4.0 of this manual. Appendix E to the Phase II RCRA Location Guidance Manual currently being developed will contain additional detailed information about these case study sites as well as other sites now being evaluated.

2.1 SITE CHARACTERIZATION

Site characterization provides the basic information that both the permit applicant and permit writer need in order to establish whether a location meets the remaining criteria for acceptability. The kind of information and the level of detail needed in a site characterization varies with the site complexity and the type of ground-water monitoring and response program (i.e., ACL demonstrations or corrective actions) applicable to the facility permit. The two performance objectives for site characterization are:

1. To provide information sufficient to determine compliance with location criteria b, c, d, and e; and

2. To provide information sufficient to predict ground-water transport and movement of constituents released should the engineered containment unit fail. If a mathematical simulation model is used, it must be able to predict contaminant time-of-travel within an error of no more than one order of magnitude.

RCRA Part B permit information requirements are set forth in 40 CFR Sections 270.14 through 270.21. The data needed to properly analyze a particular site (for example, the number, placement, and depth of observation borings) are not specified by regulation (see Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities, EPA 530 SW-84-004, May 1984 for guidance regarding data needs for proper site investigations).

Whether or not the applicant demonstrates that the above criteria are met based on the information provided in his application depends solely on a thorough review by the permit writer. An evaluation of permit applications received to date shows that sites are generally poorly characterized and the data furnished to the permit writer are deficient. The permit writer is responsible for reviewing the data submitted in the permit application, and requesting additional data if necessary, to ensure that the applicant has adequately characterized the site. Additional guidance regarding what the permit writer should look for when making this evaluation will be provided in the Phase II Location Guidance Manual now being developed (see Section 5.0 for a discussion of the Phase II Manual).

2.1.1 Geologically-Complex Locations

Certain geologically-complex locations (for example, karst terrain or fractured bedrock) will require more extensive investigation to meet the characterization performance objectives. In theory, all sites can be characterized and the dynamics of the subsurface can be described both quantitatively and qualitatively given sufficient time and effort. From a more practical viewpoint, certain sites cannot be fully characterized due to complex hydrogeologic conditions. These latter sites are locations where permits for existing facilities and expansion of existing facilities should be denied and construction of new units should be discouraged. Geologic complexity refers to variations in the three-dimensional geometry of geologic units and their physical properties as well as variations in soil mechanics and site stability. Geologically simple locations are typically characterized by a "pancake-"

like arrangement of geologic units having distinct boundaries that are easily correlated from one soil boring to another. Physical properties within each unit vary little from one part to another and physical conditions provide a stable setting. Locations become more complex when geologic units are dipping or folding, when units end abruptly or are discontinuous, when the boundaries become obscure, when physical properties vary greatly within a layer, or when soil conditions are unstable. The most complex sites are those where information about geologic units and their physical properties cannot be correlated based on boring data. In the worst case, all sub-surface features appear to be random and predictions of ground-water movement are more difficult.

When strategically placed, borings and detailed observations may provide enough information to show that a systematic pattern of subsurface layers and physical properties exists. A reliable characterization is achieved when additional borings placed between previous borings provide consistent information about site geometry and hydraulic behavior.

Terrains commonly found to be geologically complex are:

- Shallow bedrock areas composed of highly folded, fractured, or faulted formations
- Karst areas
- Alluvial materials
- Certain glaciated regions, and
- Certain High Hazard and Unstable Terrains (see Section 2.2)

2.2 HIGH HAZARD AND UNSTABLE TERRAINS

The high hazard and unstable terrain criterion illustrates the importance of locating Hazardous Waste Land Treatment, Storage, and Disposal (HWLTSD) facilities within a stable geologic environment that:

1. results in minimal ongoing maintenance after closure,
2. requires minimal physical modifications to the site, and
3. minimizes the potential for release of hazardous constituents due to ground failure and exposure to severe weather events and geologic processes.

A high hazard and unstable terrain is a location that the permit writer determines to be unacceptable due to its susceptibility to natural or man-induced events and forces capable of impairing the integrity of an engineered containment structure. These events include flooding, vulcanism, land subsidence, landslides, or seismic displacement, deformation, and ground motion. A location is likely to be considered a high hazard and unstable terrain if:

1. it is prohibited by existing location standards (i.e., the 100-year floodplain standard and seismic restriction),
2. it is experiencing existing instability (e.g., weak and unstable soils) and protective measures at the facility cannot be designed to withstand the instability, or
3. historical data indicate that an event is likely to occur at the site that would impair the engineered containment structure and protective measures cannot be designed to withstand the event (e.g., active subsidence, landslides, seismic events, or volcanic activity).

Facilities located in a high hazard and unstable terrain will frequently require perpetual monitoring and maintenance, and very likely will require extensive repairs and/or corrective action following a likely natural or man-induced event. Failure can be rapid as in the case of faulting or flooding, or gradual as with subsidence or mass movements. Although the Agency has no evidence to show that any facility can be designed to withstand natural or man-induced events that are likely to occur in the future, the permitting standards currently do not require perpetual responsibility from the owner/operator. There is no certainty that damages incurred after termination of the post-closure care period under §264.117 will be remedied.

EPA does not have specific criteria to operationally delineate all high hazard and unstable terrains at this time. The determination that a location is a high hazard and unstable terrain will be a professional judgment on the part of the permit writer. This manual, however, describes six highly sensitive areas that are considered susceptible to existing instability or future events that would impair the integrity of a facility containment structure. The following subsections describe these terrains (generally referred to as "sensitive areas") and provides guidance with respect to permit decisions in these locations. These areas are as follows:

1. Flood-prone areas
2. Seismic impact zones
3. Volcanic impact zones
4. Landslide-susceptible areas
5. Subsidence-prone areas
6. Weak and unstable soil areas

The permit writer may base his or her decision regarding site suitability in sensitive areas upon an evaluation of information on site and regional location characteristics submitted by the permit applicant. The permit writer may identify a location as a high hazard and unstable terrain unacceptable for siting based upon documented evidence of existing instability or past events in the immediate area or past events at other locations that possess similar physical characteristics that a high hazard event is likely to occur at the site. Such evidence may include statistics on the probability of an event occurring (for example, seismic activity); physical evidence of recent events such as landslides, vulcanism, or faulting; or other geologic, geomorphic, hydrologic, or pedologic data indicating that a location is likely to experience a future natural or man-induced event.

Locations determined by the permit writer to be high hazard and unstable terrains are considered unacceptable locations at which siting of HWLTSD facilities should be discouraged or prohibited on the basis of existing standards or statutes. Current regulations may provide permit writers with the authority to deny permits to facilities in locations where terrain instability already exists or the likelihood of a natural or man-induced event occurring at the site can be demonstrated using records of past activity at the site or at sites with the same geologic properties.

Permitting decisions relative to high hazard and unstable terrains may vary according to the kind of facility. The principle distinction between storage and disposal facilities located in a high hazard and unstable terrain is based on waste residence time. Current RCRA standards require that all hazardous waste must be removed from a storage unit at closure. In contrast, land disposal facilities and all waste contained within remain at a location permanently if certain design and operating standards are met.

In the description of the sensitive areas that follow, the permit writer is referred to specific existing RCRA regulations and other Federal statutes that may apply to facilities located in high hazard and unstable terrain. Details of how these regulations can be applied to specific case study sites are provided in Section 3.0 of this manual.

2.2.1 Flood-Prone Areas

Flooding can occur as a result of stream channel overflow, tide events, storm surges, and dike or dam failure. During a flood, wave action and flowing water can overtop and destroy protective dikes, erode protective covers, or undermine the containment structure and result in the washout of hazardous materials. High water levels during a flood may cause infiltration through caps or joints between caps and liners. Floods may also relocate stream channels, thereby either creating or increasing the potential for damage to facilities. Following a flood, the facility could have been damaged to an extent that subsequent floods may more easily penetrate a unit. Locations more susceptible to floods and generally within a floodplain include wind and lunar tide zone and coastal areas, areas below dams, and areas behind flood or tide dikes.

One of two existing RCRA location standards, 40 CFR Section 264.18(b), specifically addresses the location of HWLTSD facilities within the 100-year floodplain. Facilities are not permitted in the 100-year floodplain unless one of three conditions are met:

1. the facility is protected, via dikes or other equivalent measures, from washout during a 100-year flood, or
2. all hazardous materials can be removed to safe ground prior to flooding, or
3. it can be demonstrated that no adverse effects to human health and the environment will occur should flood waters reach the waste.

In addition to a location satisfying the 100-year floodplain standard, permit writers must consider Executive Order 11990 (Protection of Wetlands) for facilities located on federally-owned lands that may potentially impact wetlands in the event of a facility failure since wetland areas are frequently found in or near floodplains. A thorough presentation of the 100-year floodplain standard and the executive order is found in Section 3.1.

Permit writers should discourage the location of new HWLTSD facilities and expansions to existing units of disposal facilities within flood-prone areas and deny permits for facilities in these locations that cannot comply with the RCRA liner foundation requirements (see Section 3.2.2), the closure standard (see Section 3.2.3), or the dike integrity standard (see Section 3.2.4) as well as the 100-year floodplain standard. Facilities located in flood-prone areas pose a direct threat to surface waters, wetlands, and adjacent lands since these areas are particularly susceptible to erosion, wave action, and flooding events.

Although the 100-year floodplain standard explicitly addresses significant threats of flooding to facilities, the standard does not specifically define the types of locations that are especially flood prone. These flood-prone locations and conditions found to exist within certain land areas that are likely to be located in a 100-year floodplain are described as follows:

a. Areas Protected by Flood Control Structures

b. Coastal High Hazard Areas (barrier islands and eroding shorelines)

c. Channel Encroachment Areas

d. Wetlands

Case Study A, summarized in Section 4.0, is provided as an example to assist the permit writer in evaluating flood-prone locations. Recommended permit actions for facilities existing or proposed in such locations are described in the following subsections.

2.2.1.1 Areas Protected by Flood Control Structures

Facilities within the 100-year floodplain protected by general purpose flood control structures, exclusive of those structures satisfying the 100-year floodplain standard, may be at jeopardy should the general purpose flood control structures fail. Where a facility is located in an area protected by general purpose flood control structures, the permit writer should request that the applicant provide the following information (See 40 CFR Part 270.14(b)(11)(iii) and (iv)): (1) evaluation of the potential for structure failure, (2) resulting impact of such a failure on the facility, and (3) a map showing the elevation of the 100-year flood before and after failure relative to the location of each unit. Site conditions in the absence of general purpose flood control structures should be considered, because the feasibility of removing waste from a flooded location will generally be difficult to demonstrate.

2.2.1.2 Coastal High Hazard Areas (Barrier Islands and Eroding Shorelines) Coastal barrier islands are a special case of flood-prone area where the land may migrate in response to subtle changes in sea level. Barrier islands are a string of sand deposits shaped by wave action and storm surges occurring predominantly along the Eastern U.S. and Gulf of Mexico shorelines. Currently, barrier islands are migrating landward in response to a worldwide rise in sea level. Major changes in land configuration in these areas normally occur during severe weather and strong tropical storms. Hoffman et al. (1983) report that a global rise in sea level of between 144 centimeters (4.8 feet) and 217 centimeters (7 feet) by 2100 is most likely. Along most of the Atlantic and Gulf coasts of the United States, the rise will be 18 to 24 centimeters (0.6 to 0.8 foot) more than the global average. Land storage and disposal facilities located on a barrier island may be subjected to erosion, overwash, and eventual exposure to ocean forces as subsurface soils migrate away from the facility.

Coastal shorelines also erode at significant rates in some coastal high hazard areas. Facilities subject to shoreline erosion may be undercut and ruptured, resulting in waste washed into surface waters. Methods to control shoreline erosion are costly, require continuous maintenance, and have been known to fail during severe weather.

Where a facility is either located or proposed on a barrier island or in close proximity to an eroding shoreline, the permit writer should consider whether the facility can satisfy the 100-year floodplain standard (see Section 3.1.2). Because a facility on a barrier island is likely to be jeopardized by eroding shorelines as well as flooding, the permit writer should also consider the following existing regulations as grounds for making a decision regarding permit issuance:

- compliance with closure standards (see Section 3.2.3), and
- compliance with liner foundation requirements (see Section 3.2.2).

It is expected that a facility located on a barrier island, where erosion is likely to create unstable conditions for a liner foundation, will not comply with the above requirements. If the permit applicant cannot demonstrate that protective measures will adequately prevent erosion from occurring at such a site, permit denial is recommended. Otherwise, siting of facilities on barrier islands should generally be discouraged. Facilities in close proximity to an eroding shoreline should also be evaluated for potential impacts based upon each of the above existing RCRA standards. Land disposal facilities located in areas where evidence shows that shoreline erosion is likely are not expected to comply with the above design and operating requirements. If protective measures cannot prevent erosion from occurring in such cases, permit denial is recommended. For storage facilities, the permit writer should request a set back distance from the shoreline sufficient enough to guarantee no adverse impacts during the facility active life plus closure period. A conservative estimate of the annual erosion rate should also be considered prior to issuing a permit. Case Study A summarized in Section 4.0 illustrates a facility located in close proximity to estuarine channels that may be subject to shoreline erosion.

2.2.1.3 Channel Encroachment Areas Channel encroachment areas are those portions of the 100-year floodplain that will be subjected to erosion as the stream channel migrates. An analysis of an active floodplain may indicate meander scars and other features that prove channel migration has occurred. Only streams flowing in deep channels through massive rock are not subjected to meandering. Stream bank erosion and channel migration can be minimized with engineered structures, but cannot be prevented during the predictable future without continuous maintenance of these structures. For facilities located within a channel encroachment area, the permit writer should consider whether a facility is in compliance or will remain in compliance with the following existing RCRA regulations:

- floodplain standard (see Section 3.1.2),
- liner foundation requirements (see Section 3.2.2), and
- closure standard (see Section 3.2.3).

The permit writer should base permit issuance decisions on documented evidence regarding stream channel migration in the area.

Because channel encroachment areas are locations characterized by continuous physical change, it may be difficult for owner/operators of storage and disposal facilities to comply with the liner foundation and closure requirements over the active life of a unit and the closure and post-closure periods. If documented evidence shows that encroachment at the site is likely during this period and if the facility cannot be designed to mitigate encroachment impacts, permit denial is recommended for proposed facilities, existing facilities, or expansions in these locations. Because channel encroachment areas may be hydrogeologically complex and are characterized by relatively permeable soils, the following should be required before issuing a permit to existing facilities in these locations: (1) Contingent Corrective Action Programs (see Section 3.3.2), and (2) monitoring of channel migration.

2.2.1.4 Wetlands Portions of the 100-year floodplain may be composed of wetlands that frequently become flooded. On December 18, 1978, the Agency proposed a location standard for wetlands but the standard was never promulgated because wetland protection was partially addressed under the dredge and fill program administered by the U.S. Army Corps of Engineers (COE) pursuant to Section 404 of the Clean Water Act. The permit writer is responsible for coordinating with the Corps to assure that the COE properly determines whether or not a permit applicant is in compliance with the requirements of the Clean Water Act. The permit writer should also consider whether an owner/operator of a facility located on federally-owned land is in agreement with the directive under Executive Order 11990 entitled, "Protection of Wetlands", published on May 24, 1977.

Wetlands are often characterized by organic soils or other weak soil conditions (see Section 2.2.5). Concerns for the impact of HWLSD facilities on wetlands are also discussed under Protected Lands (see Section 2.5.6). Case Study A in Section 4.0 is provided as an example to assist the permit writer in evaluating locations characterized by wetlands.

2.2.2 Seismic Impact Zones

Seismic impact zones are locations subject to surface deformation, ground shaking, landslides, ground failure, and subsidence resulting from a seismic event. Surface faulting, the permanent horizontal and/or vertical displacement of the ground, is one manifestation of a seismic event. The impact zone may be characterized by a complex of main faults, branch faults, secondary faults, and associated deformation features as well as ground motion.

Land storage and disposal units located directly over a fault may become damaged due to rupture during fault displacement. Units located in close proximity to the fault zone may be damaged due to ground shaking and associated ground failure or subsidence. Ground shaking may cause differential settling of waste within the facility or the ground supporting the facility, resulting in rupture of the liner, leachate collection pipes, or cover materials. Ground motion may also cause damage to impoundment dikes, especially at existing units where weak, unconsolidated soils were used as dike materials. Weak and unstable soils may liquify, lose strength, lurch, settle, or slide impairing the structural integrity of dikes (see Section 3.2.4 on the Dike Integrity Standard and Section 2.2.6 on weak and unstable soils for existing units in seismic impact zones). In regions that have experienced significant seismic activity (see Zones 2 and 3 in Figure 2.2.2-1), seismic impacts must be considered in the design of new as well as existing units whose damage or failure could cause widespread adverse impacts on human health and the environment.

Seismic impacts to units may occur in two forms: the direct tearing of structures that lie on the fault and the acceleration of structures within the zone of more intense motion. Preliminary estimates of the seismic activity experienced in the continental United States is illustrated in the map of earthquake zoning (see Figure 2.2.2-1). The zones reflect the level of engineering consideration needed to ensure good facility design. In Zone 0, experience suggests no influence of seismic activity on facility design. Zone 1 suggests nominal effects from distant earthquakes or very small local events. Seismic impacts should be considered in unit design only if local conditions of subsurface geology (i.e. faulting) at the site warrant it or if static analysis of a dike or a dam stability analysis results in a minimum acceptable factor of safety. Zone 2 implies moderate intensities equivalent to accelerations as great as 0.15g. The effect of seismic activity in this zone should be considered in the design of all facility structures by semiempirical methods. Zone 3 encompasses all larger earthquakes whose effect should be evaluated by dynamic analyses. Depending on local conditions of the location, permit writers should especially consider what effects seismic impacts may have upon designed facilities located or proposed in Zones 2 and 3.

An existing RCRA location standard under 40 CFR Part 264.18(a) prohibits the location of any portion of a new HWLTSD facility within 61 meters (200 feet) of a fault active in the Holocene (during the last 10,000 years). The standard does not address the impact of landslides or ground failure that may occur at new and existing facilities affected by seismic impacts. These conditions are addressed in subsequent sections of this guidance manual concerning landslide-prone areas, subsidence-prone areas, and weak and unstable soil areas. Case Study A summarized in Section 4.0 illustrates a seismic zone location.

2.2.3 Volcanic Impact Zones

Volcanic activity occurs within well-defined regions and poses varying degrees of hazard. The type of volcanic activity is determined by the composition of the magma and the magma gas content. Basaltic magmas typical of the Hawaiian Island volcanoes are nonexplosive and form gently sloping shield volcanoes. Felsic (rhyolite and andesite) magmas tend to be viscous and contain volatile gas that cause explosive eruptions. Mt. St. Helens and other volcanoes of the Pacific Northwest are the steep-sided composite volcanoes

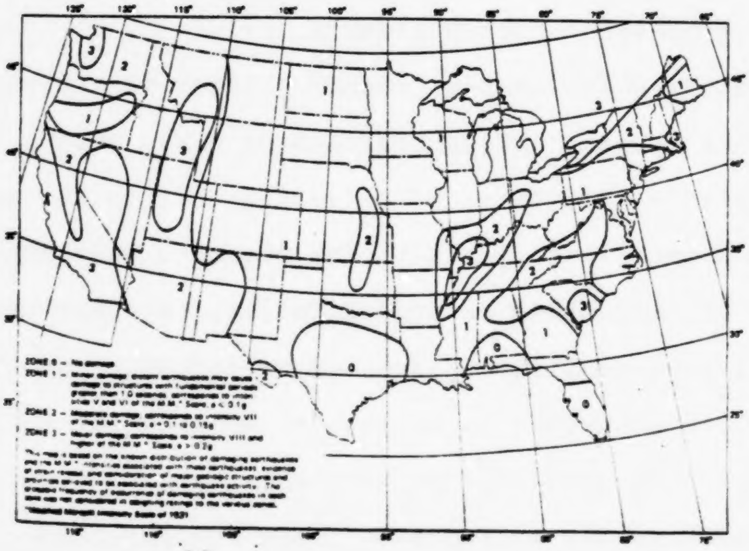

ZONE 0 – No damage
ZONE 1 –
ZONE 2 –
ZONE 3 –
0
1
2
3

FIGURE 2.2.2-1: SEISMIC ZONING IN THE UNITED STATES
(Algermissen, 1969)

typical of felsic magmas. The release of pyroclastic magma, ash, and lava in an eruption can be accompanied by mud flows, floods, and avalanches.

Land treatment, storage, and disposal facilities subjected to volcanic activity may be washed out or eroded by flood or mud flow, buried by ash or magma, ruptured by ejected material or impacted by avalanches. Run-off/run-on control and monitoring systems, for example, may be especially susceptible to damage from debris flow.

Geologic evidence will indicate the relative activity of a volcano, and based upon this evidence, a determination can be made about whether volcanic impacts are likely to occur at a facility location. Although there is no way of predicting the exact time of an eruption, the U.S. Geological Survey (USGS) has delineated zones susceptible to floods, mud flows, lava flows, and ejected material for the active volcanoes in Hawaii and the Pacific Northwest. Figure 2.2.3-1 illustrates volcanic impact zones of the forty eight conterminous United States (Mullineaux, 1976). Permit writers in EPA Regions IX and X should become familiar with these areas to determine whether a proposed or existing facility location is likely to be impacted by volcanic activity. Subsurface and surficial conditions such as weak and unstable soils, faulting, and landsliding that may be more conducive in areas of active volcanoes and that may impact designed structures should also be considered. Information concerning volcanic impact zones can be obtained from the USGS Volcano Hazards Program and the State Geologist. Technical assistance from the U.S. Geological Survey should be requested from:

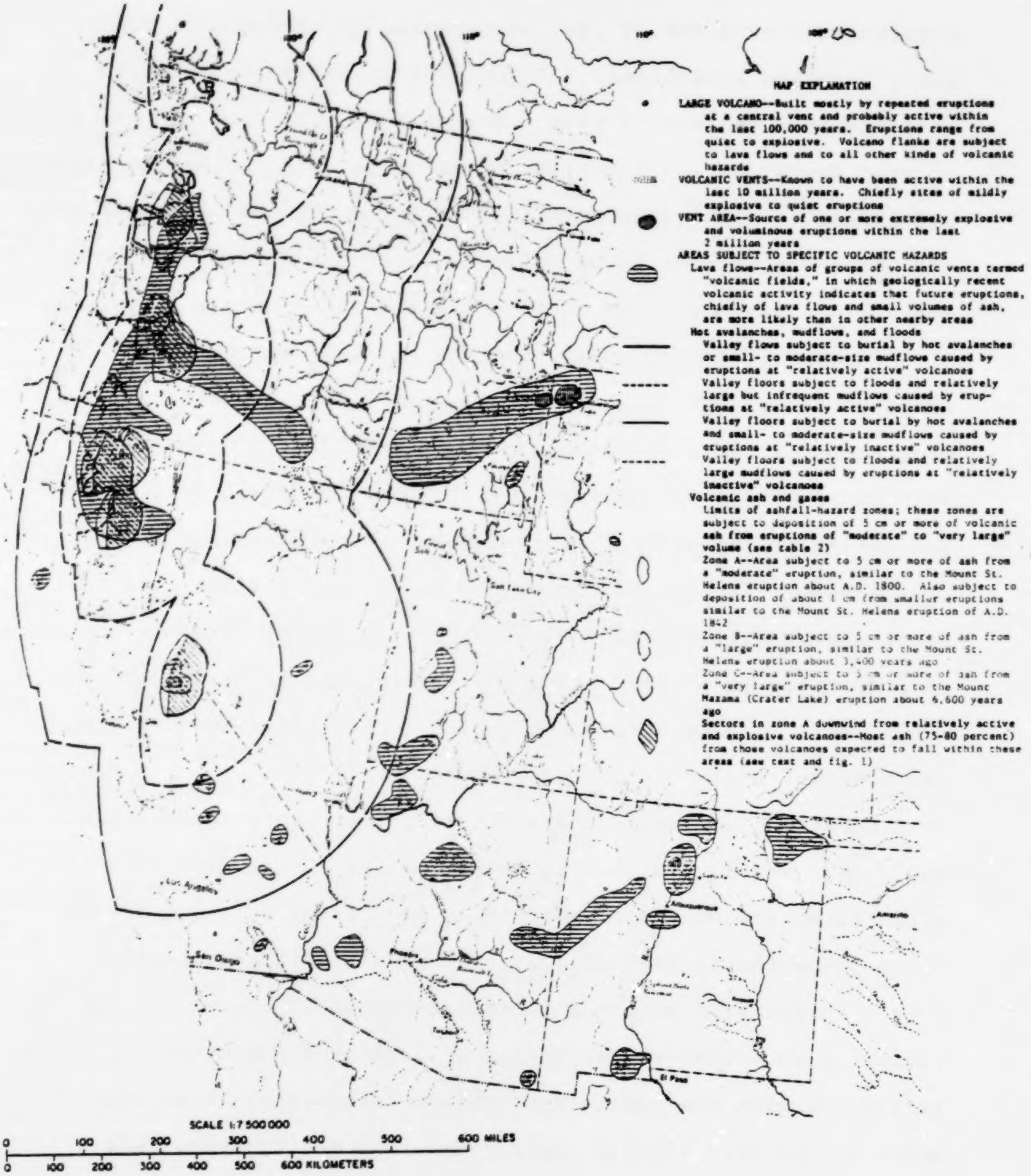
Coordinator, Volcano Hazards Program
U.S. Geologic Survey
345 Middle Field - Mail Stop 910
Menlo Park, California 94025
(415) 323-8111

Because volcanic eruptions are difficult to accurately predict, it is unlikely that a permit writer will have a basis for denying a permit due to the risk of volcanic eruption unless documented evidence of existing or very recent volcanic activity in the area is available from the USGS. If USGS data indicate that volcanic activity is likely to occur at a particular facility location and the facility is not designed to withstand volcanic impacts, the permit writer should discourage the siting of new facilities, expansion of existing facilities, and the continued operation of existing facilities in such a location. For facilities located in areas where evidence of existing or very recent volcanic activity exists, the permit writer should consider whether the facility will remain in compliance with the following existing RCRA regulations:

- Compliance with the closure standard (see Section 3.2.3)
- Compliance with liner foundation requirements (see Section 3.2.2)

2.2.4 Landslide-Susceptible Areas

The rapid mass movement of earth materials called landslides, rock falls, mudslides, slumps, earth flows or debris flows, are reported for most steeply sloping lands in the United States. The timing and extent of a landslide cannot be exactly predicted; however, areas susceptible to such events may be characterized by



MAP EXPLANATION

● **LARGE VOLCANO**--Built mostly by repeated eruptions at a central vent and probably active within the last 100,000 years. Eruptions range from quiet to explosive. Volcano flanks are subject to lava flows and to all other kinds of volcanic hazards

VOLCANIC VENTS--Known to have been active within the last 10 million years. Chiefly sites of mildly explosive to quiet eruptions

● **VENT AREA**--Source of one or more extremely explosive and voluminous eruptions within the last 2 million years

AREAS SUBJECT TO SPECIFIC VOLCANIC HAZARDS

▨ Lava flows--Areas of groups of volcanic vents termed "volcanic fields," in which geologically recent volcanic activity indicates that future eruptions, chiefly of lava flows and small volumes of ash, are more likely than in other nearby areas

Hot avalanches, mudflows, and floods

— Valley flows subject to burial by hot avalanches or small- to moderate-size mudflows caused by eruptions at "relatively active" volcanoes

- - - Valley floors subject to floods and relatively large but infrequent mudflows caused by eruptions at "relatively active" volcanoes

— Valley floors subject to burial by hot avalanches and small- to moderate-size mudflows caused by eruptions at "relatively inactive" volcanoes

- - - Valley floors subject to floods and relatively large mudflows caused by eruptions at "relatively inactive" volcanoes

Volcanic ash and gases

Limits of ashfall-hazard zones; these zones are subject to deposition of 5 cm or more of volcanic ash from eruptions of "moderate" to "very large" volume (see table 2)

Zone A--Area subject to 5 cm or more of ash from a "moderate" eruption, similar to the Mount St. Helens eruption about A.D. 1800. Also subject to deposition of about 1 cm from smaller eruptions similar to the Mount St. Helens eruption of A.D. 1842

Zone B--Area subject to 5 cm or more of ash from a "large" eruption, similar to the Mount St. Helens eruption about 3,400 years ago

Zone C--Area subject to 5 cm or more of ash from a "very large" eruption, similar to the Mount Mazama (Crater Lake) eruption about 6,600 years ago

▨ Sectors in zone A downwind from relatively active and explosive volcanoes--Most ash (75-80 percent) from those volcanoes expected to fall within these areas (see text and fig. 1)

FIGURE 2.2.3-1: Volcanic Impact Zones of the Forty Eight Conterminous United States (Mullineaux, 1976)

considerable evidence of past occurrences or by geologic conditions favoring landslides. A landslide could impact a HWLTSD facility in a variety of ways. For example, the facility may be carried downslope and ruptured and/or mixed with the moving earth materials; it may become partially or fully ruptured in place and the waste exposed; or it may also be covered and compressed, thus destroying run-on/run-off control systems and monitoring systems.

A generalized map indicating the relative susceptibility of areas to landslides is shown in Figure 2.2.4-1. More detailed maps prepared for a few communities by the USGS in cooperation with state geological surveys must be used by permit writers when evaluating if landslide susceptibility potential exists at a site. The permit writer should contact both the USGS and the appropriate state survey for assistance in identifying landslide-prone areas in a specific location. Landslide susceptibility is judged from slope, soil, geologic, and meteorologic conditions by qualified geotechnical engineers and geologists.

Locations for which there exists geomorphic evidence that rapid mass wastage is likely, either on the moving mass or in the slide path, are not expected to meet any of the existing regulations presented in Section 3.2. The permit writer suspecting that a facility is within a landslide-susceptible area should request a geotechnical evaluation of landslide potential in accordance with the permit application information requirements under 40 CFR Part 270 for liner foundation requirements (see Section 3.2.2), the closure standard (see Section 3.2.3), or the dike integrity standard (see Section 3.2.4). If such an evaluation indicates that a landslide is likely at the site, that the facility cannot be designed to withstand the landslide, and that the liner foundation standard, the dike integrity standard, or the closure requirement cannot be satisfied, the permit should be denied by the permit writer.

2.2.5 Subsidence-Prone Areas

The principle locations where land subsidence is likely to occur are areas of fluid withdrawals, karst terrains, and subsurface mining. Facilities subjected to subsidence can be ruptured, deformed, or otherwise damaged such that waste is directly released to the environment or migration of waste already leaking from a facility is enhanced. A sudden event is not a prerequisite for failure of the facility's protective containment due to subsidence. In certain cases, faulting or surface deformation may damage the facility structure over a period of years without obvious manifestations of failure. Also, subsidence-prone areas may be difficult locations to monitor or in which to implement a corrective action, due to extensive, uncharacterizable secondary porosity flow paths (e.g., mine tunnels, earth fissures, and solution cavities).

As of October 1983, eight States prohibit or limit the location of hazardous waste land disposal operations in mining or subsidence-prone areas. These States are Arizona, Arkansas, Delaware, Illinois, Maryland, New Jersey, Pennsylvania, and West Virginia. Nine States also prohibit or limit the location of facilities in karst/carbonate areas. These States are Arkansas, Delaware, Kentucky, Maryland, Minnesota, Missouri,

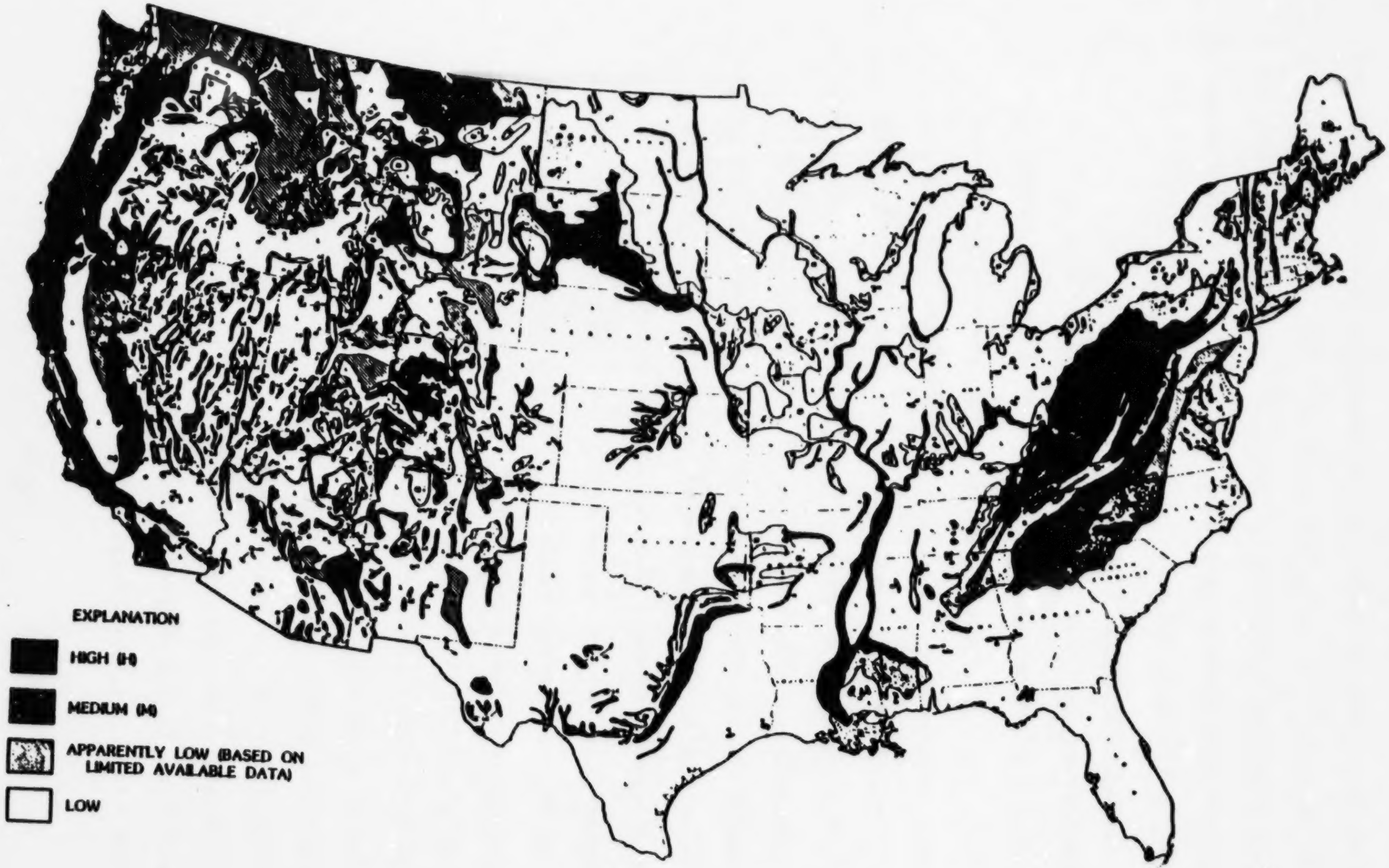

EXPLANATION
HIGH (H)
MEDIUM (M)
APPARENTLY LOW (BASED ON LIMITED AVAILABLE DATA)
LOW

FIGURE.2.2.4-1: Map showing relative potential of different parts of the conterminous United States to landsliding (Wiggins and others, 1978).

New Jersey, Pennsylvania, and West Virginia. The States have various definitions for these site characteristics (Monnig, 1984).

The permit writer should discourage new HWLTSD facilities and proposed expansions to existing facilities from locating in subsidence-prone areas. For new facilities, the permit writer should determine if the seismic restriction is applicable in such locations (see Section 3.1.2). In subsidence-prone areas not governed by the seismic standard, permits may be denied at new and existing facilities that cannot be designed to withstand subsidence and consequently, cannot comply with the following RCRA standards:

- Ability to Monitor Requirement (see Section 3.2.1),
- Liner Foundation Requirement (see Section 3.2.2) (new units and new portions of existing facilities), and
- Closure Standard (see Section 3.2.3).

2.2.5.1 Fluid Withdrawal Zones The withdrawal of oil, gas, and ground water can result in land surface subsidence and the formation of associated earth fissures and surface faults. Earth fissures and faults occur due to the compaction of unconsolidated sediment as fluid is withdrawn. Subsidence features may not necessarily occur directly over the cone of depression of a ground-water well, for example, but may appear on adjoining lands due to variations in subsurface conditions. Holzer (1984) in a review of ground failure related to ground-water withdrawal found that earth fissures commonly have lengths of several hundred meters and are commonly eroded to a width of one to three m into gullies at the surface. Faults were found to be a kilometer or more long with vertical offsets of 0.5 m. The rate of growth of fissures and faults is relatively slow.

Subsidence may impact HWLTSD facilities in several ways. Faulting may rupture the liner systems or cause differential settlement within the facility. Earth fissures serve as planar conduits for infiltrating water, and may route leaking waste past monitoring wells or otherwise complicate ground-water flow. Subsidence may change drainage patterns, increase run-on, or increase the probability of flooding.

A generalized map identifying 14 regions known to be subsiding as a result of fluid withdrawal is shown in Figure 2.2.5.1-1. The permit writer should use this map only as a general reference and should not attempt to make a site specific determination based upon this information. Subsidence impacts can be predicted to some extent at the site specific level by two approaches: (1) recognition of appropriate subsurface conditions at the location, and (2) monitoring of surface deformation for precursory signals.

Permit writers should investigate the possibility of subsidence and subsidence impact occurring at any facility in the southwest U.S. extending over a region from the Houston area to California. Permitting of new facilities to be located in such subsidence-prone locations should be discouraged or denied as appropriate if documented evidence indicates that subsidence is likely at the location. Owners or operators of existing facilities located in subsidence-prone areas that cannot demonstrate through documented observations that earth fissures and faulting during the active life of the facility have not occurred should be discouraged from continued operation or expansion if the

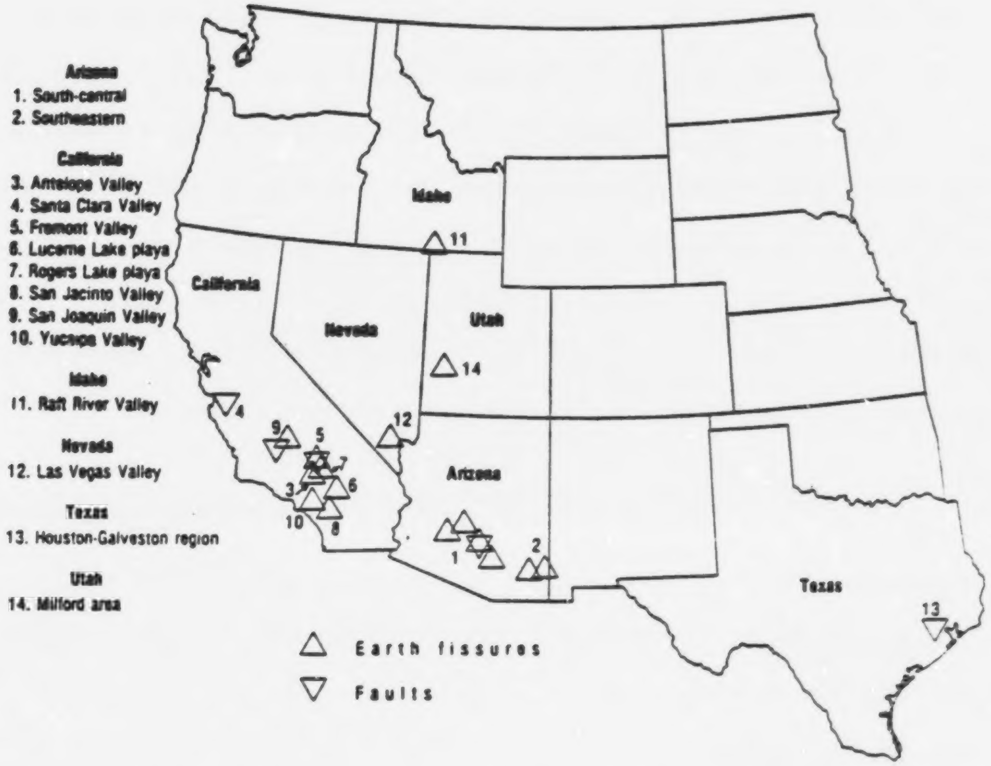

Arizona
1. South-central
2. Southeastern
California
3. Antelope Valley
4. Santa Clara Valley
5. Fremont Valley
6. Lucerne Lake playa
7. Rogers Lake playa
8. San Jacinto Valley
9. San Joaquin Valley
10. Yucaipa Valley
Idaho
11. Raft River Valley
Nevada
12. Las Vegas Valley
Texas
13. Houston-Galveston region
Utah
14. Milford area
Idaho
California
Nevada
Utah
Arizona
Texas
1
2
3
4
5
6
7
8
9
10
11
12
13
14
△ Earth fissures
▽ Faults

FIGURE 2.2.5.1-1: Fluid withdrawal ground failure areas (after Holzer, 1984).

facility cannot be designed to withstand the subsidence. Such evidence may also be used with other information to determine whether a facility is in compliance with the RCRA seismic standard (see Section 3.1.2), the liner foundation requirement, (see Section 3.2.2), monitoring standards (see Section 3.2.1), 3.2.1), or the facility closure requirement (see Section 3.2.3).

2.2.5.2 Karst Terrain. Areas underlain by limestone and dolomite are often characterized by extensive solution cavities, sinkholes, and other features. These locations are referred to as karst terrain, karst topography, or a karst plain. Thornbury (1969) provides a thorough description of karst topography and states four conditions that maximize development of karst features. These are (1) a soluble rock such as limestone must be present or at near ground surface, (2) the soluble rock should be dense, highly jointed, and thinly bedded, (3) valleys entrenched into the soluble rock exist, and (4) the region is subject to at least moderate rainfall. Ground water moving in the joint spaces allows the soluble rocks to dissolve, leaving solution channels that expand with time.

Commonly found in karst terrains, sinkhole formation is an infrequent but destructive event that could cause rupture of unit liners and covers and eventual collapse of the facility. Lowering ground-water levels via water supply pumping or land drainage can accelerate the process of sinkhole collapse. A karst terrain is also characterized by extensive secondary porosity capable of transmitting large quantities of ground-water through complex, unpredictable pathways. Solution channels may also connect via 'pipes' through overburden materials and intercept streams or other runoff (e.g., disappearing streams).

Permit writers should consider the ability of owners or operators of new facilities and expansions of existing facilities to properly monitor ground-water quality in karst terrains (see also Section 2.3) as grounds for permit denial. Permit writers should also consider permit denial in the case of existing units if the owner or operator cannot demonstrate the ability of the liner, cover, or other engineered features of the unit to withstand potential subsidence in karst terrains (see Sections 3.2.2 and 3.2.4).

2.2.5.3 Mine Subsidence Areas The collapse of mine tunnels often results in surface subsidence, particularly where the mines are close to ground surface. To date, approximately one quarter of subsurface mining areas have been affected by subsidence according to the U.S. Bureau of Mines (GAO, 1976). The magnitude, extent, and temporal occurrence of mine subsidence depends upon the thickness and strength of overlying strata, mine geometry, duration and rate of mining, and the sequence of mining operation (Dunrud, 1976). In addition to mine tunnel collapse, collapse of partially plugged, unrecorded mine shafts have also been reported. While the mine may not fully collapse, partial subsidence results in earth fractures that can propagate through hundreds of meters of strata (Dunrud, 1976).

Subsurface mines pose an additional concern to the location of land storage and disposal facilities, due to the complexity of ground-water transport within flooded mine tunnel networks, and within the fracture pattern that develops in the overlying materials. Permit writers should consider the ability of the owner or operator to meet the ground-water monitoring criterion (see Section 2.3) and other existing unit-specific design and operation requirements (i.e., liner and cover standards) in locations susceptible to or experiencing mine subsidence. Case Study B summarized in Section 4.0 is provided as an example to assist the permit writer in evaluating a mine subsidence area.

2.2.6 Weak and Unstable Soils

Weak and unstable soils will not provide the proper foundation for supporting a HWLTSD facility or the proper material necessary for constructing stable embankments. Facilities located on these soils may be subject to differential and excessive settlement that will tear liners, rupture dikes, render leachate collection systems inoperable, and possibly alter the ground-water flow system. Specific design and operating requirements for various facilities, for example, require that liners must be placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients to prevent failure of the liner due to settlement, compression, or uplift (see unit-specific requirements under Sections 264.221, 264.251, and 264.301). Radical modifications to a site may be required to compensate for weak and unstable soils that do not provide the proper liner foundation, base, or stable dike material. The principle modification is usually complete removal or replacement of the low quality earth material.

Geotechnical engineers recognize seven soils or conditions, that, when present beneath a facility, may result in weak and unstable foundation conditions. These soils and conditions are the following: (1) organic soils, (2) expansive soils, (3) liquifaction sands, (4) soft clays, (5) sensitive clays, (6) loess, and (7) quick conditions. The presence of these soils and conditions can be predicted from a knowledge of regional geology and site investigation. Although deposits of weak and unstable soils have been identified in numerous locations, these soils are commonly found in recent unconsolidated deposits such as bay mud, and in locations such as floodplains and deltas. The permit writer should determine whether the facility is in compliance with the liner foundation requirement (see Section 3.3.2), facility closure requirement (see Section 3.2.3), or the dike integrity standard (see Section 3.2.4). A brief description of each soil type and its significance is presented in the following subsections.

2.2.6.1 Organic Soils Soils with a significant content of decaying vegetation can be expected to compress under the weight of land storage and disposal facilities. Having a significant organic carbon content as low as ten percent, these soils are classified as OH, OL, or Pt (peat) under the Unified Soil Classification System and may also be referred to as mucks, swamps, wetlands, or marshes. Under the USDA soil classification system, organic soils are classified as Histosols. Organic soil deposits are commonly found in most humid environments along riverine, lacustrine, and estuarine systems. Organic soil deposits may be shallow or as deep as tens of meters and range in size from less than an acre to several square miles. Unless the deposit is very thin and deeply buried, these materials should be excavated prior to construction (see Case Study A summarized in Section 4.0 for an example of a location having this type of weak and unstable soil).

2.2.6.2 Expansive Soils Soils with a significant content of shrink-swell clays, such as montmorillonite, will dramatically change in volume depending upon moisture content. Shrink-swell clays that have dessicated will possess cracks and upon wetting, the soil material will swell and the cracks will close. Locations characterized by expansive soils may provide uneven foundation support where hazardous waste units are constructed on such soils. Large increases in permeability upon exposure to many organic solvents is also a concern. Expansive soil deposits tend to be thin and should be excavated prior to construction.

2.2.6.3 Liquefaction Sands Loosely compacted, saturated sands characterized by round, smooth grains, are susceptible to liquefaction when subjected to ground motion (generally due to a seismic event). Ground motion causes the rearrangement of the sands into a denser configuration. Immediately following a ground motion, the sand particles compact to a depth below the natural ground-water table and no longer support the surficial materials or structures above the water table. The overlying materials or structures are thus supported temporarily only by water, hence the term "liquefaction," and are susceptible to sliding or shear failure. Soils may also liquefy if excessive vibration, e.g. traffic, occurs on or adjacent to the affected area. Liquefaction sands are limited in extent.

2.2.6.4 Soft Clays Clays and mixtures of clay and sand may possess very low compressive strength and are very susceptible to shear failure and compression. Called soft or very soft clays, these materials give an unconfined compressive strength of under 500 pounds per square foot or a standard penetration test count of less than four. The potential for foundation failure is greatest when a facility extends above grade. Slope stability for dikes and embankments requires thorough examination (See Case Study A summarized in Section 4.0 for an example of a location having this type of weak and unstable soil).

2.2.6.5 Sensitive Clays Upon recompaction, certain clays are weaker than they were in an undisturbed state. Soils that are four or more times weaker in the disturbed state are referred to as "sensitive." In some cases, soils may be weaker by a factor of 20 times in the disturbed state. Sensitive clays are suspected when Atterberg limits show a very high liquid limit and an in-situ moisture content near the liquid limit. Some sensitive clays contain a large proportion of organic materials. Compensatory engineering to be relied upon in locations having sensitive clays include removal of clay, special facility design, precautions to ensure that the clays are not disturbed, and limiting facility elevation above the natural grade.

2.2.6.6 Loess Wind deposited materials called loess, with grain sizes of .005 to .02 millimeters, have very strong intergranular bonding. The bonding can be weakened upon wetting which results in settlement and a loss in bearing strength. The bond may also weaken due to seismic shock. Bearing strength is also naturally variable in loess deposits. A loss in strength may eventually result in landslide, differential settlement, or slope failure. Major loess deposits are found in the mid- to lower-Mississippi-Missouri Valley and in southeastern Washington State. Engineering methods used to compensate for such conditions include compaction, drainage, or removal of deposits.

2.2.6.7 Quick Conditions Saturated cohesionless (sands) or low cohesion (including clays) soils subjected to pore water pressures greater than or equal to intergranular stress will result in a quick condition. Typically, the hydraulic gradient in the cohesionless material is vertical upward (known as a ground-water discharge location). Loads placed on the soils under a quick condition will be supported only by pore water, and soils will settle to the extent they are not made buoyant due to pore water pressure. Liner failure and slope instability are two potential disruptions that may result in units located in areas having quick conditions. Areas composed of unconsolidated sediment and artesian aquifer conditions are susceptible to quick conditions. Compensatory engineering may involve high maintenance water management systems such as site drainage.

2.3 ABILITY TO MONITOR AT THE LOCATION

The monitoring criterion is a critical consideration when making a determination on both the acceptability of a location and permit issuance. A setting must meet the ground-water monitoring standards established in 40 CFR Sections 264.92 and 264.97 in order to meet the third criterion for an acceptable location. General monitoring requirements specify that the ground-water monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths, to yield ground-water samples from the uppermost aquifer that represent the following:

1) the quality of background water that has not been affected by leakage from a regulated unit, and
2) the quality of ground water passing the point of compliance.

In addition, the owner or operator must comply with permit conditions that ensure that hazardous constituents under Section 264.93 entering the ground water from a regulated unit do not exceed the concentration limits under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance during the compliance period. Whether a facility is in a location that is conducive to ground-water monitoring can be determined on the basis of four tests described below.

In the first test, the uppermost aquifer must be identified and the rate and direction of ground-water flow within the uppermost aquifer must be specified as required under Section 270.14(c)(3). Many permit applicants fail to provide this information in the initial submission of a permit application. If the permit applicant fails to provide adequate information to correct deficiencies in the permit application after a reasonable period, the permit writer should consider the deficiencies as grounds for permit denial.

To meet the second test, the ground-water pathway(s) for hazardous constituents that may leak from the facility at failure must be described. This test requires a detailed characterization of the ground-water flow system. Except for the most simple geologic systems, the flow system characterization may require a flow net analysis (to be described in the Phase II location guidance manual and Appendix B to that manual). In certain circumstances, a simulation of contaminant transport using an accepted numerical or analytical model calibrated to specific site conditions may be appropriate. Locations where the pathways that hazardous constituents would follow in the event of release from the regulated unit cannot be concisely determined are considered complex settings, and therefore, cannot be readily monitored. At such locations, permits should be denied on the grounds that the location cannot be monitored unless an exemption from ground-water monitoring requirements is appropriate under 40 CFR Section 264.90 (b)(1),(2), and (4). Case studies B and D are provided as examples of applications that fail the second test in this way (see Section 4.0).

The third test involves the identification of background ground-water monitoring sites. This test is an expansion of the flow-path test to determine upgradient or off-gradient background monitoring well sites. Upgradient background wells are preferred for a monitoring network designed to detect migration of soluble contaminants; however, upgradient background wells may not always be feasible. Some situations that require special attention include:

- waste management areas that are located above water-table mounds,
- waste management areas located above aquifers in which ground-water flow directions change seasonally,
- waste management areas located above aquifers in which ground-water flow directions change due to tides,
- waste management areas that are located close to another facility's property boundary that is in the upgradient direction, and
- waste facilities containing significant amounts of insoluble and low soluble contaminants with densities greater than water.

In these and other situations that may arise, the regulations allow the specification of background wells that may or may not be upgradient (i.e., off-gradient). The specification of background well location and depth in these situations must meet two requirements:

- the wells must be located and completed at points least likely to be contaminated should a leak occur, and
- a procedure for evaluating whether or not the background wells are themselves contaminated must be developed.

Guidance concerning the identification of background monitoring well sites and monitoring requirements is found in the "RCRA Draft Permit Writers' Manual on Ground-Water Protection; 40 CFR Part 264, Subpart F." Generally, the identification of background monitoring well sites by the permit applicant should be feasible. In the rare case where background well locations cannot be established, permit denial is required (unless an exemption is obtained under 40 CFR §264.90 (b)).

The fourth test concerns the practicality of placing monitoring wells. Generally, accessible locations at a site exist for locating both monitoring and background wells. In certain rare instances, however, appropriate sites for background or downgradient monitoring wells may be inaccessible due to rough terrain, protected land restrictions, or an inability by facility owner/operators to purchase property rights (necessary when there is insufficient space on the owner's property outside the waste management area). Where such on-site conditions present major obstacles in developing a ground-water monitoring system that provides prompt information on the presence and extent of ground-water contamination below the facility, the permit writer should consider permit denial unless an exemption from monitoring requirements is obtained under 40 C.F.R. Section 264.90(b).

2.3.1 Minimal Recharge Zones

Although appropriate conditions for an exemption from ground-water monitoring would need to be evaluated by the permit writer on a case-by-case basis, locations at which recharge to ground water is minimal may be considered as one possible setting where this exemption may be especially appropriate. A minimal recharge zone is a land area that contributes negligible quantities of water for ground-water recharge. Minimal recharge zones are found only in arid regions like the Basin and Range physiographic province. Within the Basin and Range areas, moisture accumulates as snow at mountain ridges of high elevation that envelope the basins. Spring snow melt discharges off the mountains in small streams. However, the mountain streams do not reach the basins except during rare storm events. The stream flow essentially dries up on the alluvial fans as the discharging waters soak into the stream channel as recharge to the ground-water system. The upland areas located between the dry streams beds are typically minimal recharge zones. Although recharge generally occurs within narrow reaches of mountain stream channels on the alluvial fans, run-on and drainage into topographical depressions or geophysical anomalies, and vertical migration below the root zone and the capillary area, may all lead to recharge even in arid climates. Case Study C summarized in Section 4.0 illustrates a minimal recharge location in the western United States.

Water movement in arid recharge zones occurs in a predominantly vertical, cyclic pattern. During infrequent rain events, moisture infiltrates into the dry soil. Subsequent periods of high evapotranspiration (E-T) remove the soil moisture. The entire moisture cycle operates in a thin surface soil horizon between two to three feet thick. Moisture within a land disposal facility will move vertically upward, primarily in response to E-T demand.

To determine whether or not a minimal recharge zone exists in a particular area requires a long term record of potential evapotranspiration (PET), actual evapotranspiration (AET), and precipitation (P). This data is generally available through local weather service stations and the National Oceanographic and Atmospheric Agency (NOAA). As a general rule, a minimal recharge zone is more likely to exist where PET > P plus AET (precipitation + surface runoff) during any month although vertical recharge may occur in desert climates where the PET far exceeds the P plus AET in certain settings. In order to further verify minimal recharge at a site, water mass balance, water dating studies, unsaturated zone monitoring, and other techniques may be useful to the permit writer in evaluating a location.

Minimal recharge zones are also associated with thick unsaturated zones. Facilities in these zones may be well suited for an exemption from the ground-water protection standards under 40 CFR Section 264.90(b)(4). In addition, due to the very low rainfall in these zones, the quantity of leachate generated at a facility is small.

States where minimal recharge areas may be found include:

- Arizona
- California
- Colorado (western)
- Idaho
- Nevada
- New Mexico
- Oregon (eastern)
- Texas (western)
- Utah
- Washington (eastern)
- Wyoming (western)

The minimal recharge criterion and potential for an exemption from Part 264 Subpart F should only be considered for landfills and waste piles with liners and leachate collection and removal systems that comply with the Part 264 standards. Surface impoundments or any facility that receives liquid waste should not be considered since the presence of these liquids may represent a significant component of recharge to the ground water.

2.4 PROTECTED LANDS

The protected land criterion alerts permit writers to consider other existing Federal statutory restrictions on certain lands when issuing permits to facility owners or operators. Protected lands may include the following:

1. Archaeological and Historic Places
2. Endangered and Threatened Species Habitat
3. National Parklands
4. Wetlands
5. Wilderness Areas
6. Wildlife Refuges
7. Coastal Areas
8. Significant Agricultural Lands

40 C.F.R. Section 270.3 provides that permits be issued in a manner and with conditions consistent with requirements of the following applicable Federal laws: the Wild and Scenic Rivers Act, the National Historic Preservation Act of 1966, the Endangered Species Act, the Coastal Zone Management Act, and the Fish and Wildlife Coordination Act. When any of these laws is applicable, its procedures must be followed. When the applicable law requires consideration or adoption of particular permit conditions or requires the denial of a permit, those requirements also must be followed. Section 270.3 informs the permit writer of requirements that exist under laws other than RCRA that may be applicable to his or her permit decisions.

HWLTSD facilities may be wholly prohibited from locating in areas like National Parks and Wilderness Areas under Federal statutory requirements other than RCRA. For some protected lands, such as sites listed or eligible for listing on the National Register of Historic Places, facilities may only be required to mitigate direct impacts. Other protected land restrictions may require the applicant to simply obtain a permit. Wetlands regulated under Section 404 of the Clean Water Act are an example where a permit is necessary before siting a facility. Many States now have wetland protection statutes that have provisions which may exceed the Section 404 requirements. Permit writers should coordinate with the States to ensure that the appropriate provisions are met.

New HWLSD facilities should not be located on protected lands. RCRA permit writers should deny RCRA permits for existing facilities that are not in compliance with the protected land statutes, if required permits or permission from the appropriate regulatory authority have previously been denied. The National Environmental Policy Act (NEPA) regulations implemented under 40 CFR Part 6 (Subpart C) by the Environmental Protection Agency describe more specifically various Federal laws and executive orders that apply to protected lands. Permit writers should coordinate with the NEPA Compliance staffs in the Regions as well as with the appropriate Federal agencies to encourage routine consultation regarding the applicability of various protected land statutes in facility permitting. The protected land statutes and regulations are listed in Table 2.4-1.

The following subsections briefly describe various types of protected lands and cites the applicable statutory authority and restrictions that apply in permitting the HWLSD facilities. Case Study A summarized in Section 4.0 highlights a facility

TABLE 2.4-1: PROTECTED LAND STATUTES AND REGULATIONS

CRITERIA FOR LOCATIONAL ACCEPTABILITY	STATUTES/REGULATIONS
PROTECTED LAND:	
- ARCHAEOLOGICAL/HISTORIC PLACES	National Historic Preservation Act (NHPA) of 1966: 16 U.S.C. §§470 et seq.
- ENDANGERED/THREATENED SPECIES	Endangered Species Act of 1973; 16 U.S.C. §§1531-1543
- PARKS, MONUMENTS, AND RIVERS	Wild and Scenic Rivers Act; 16 U.S.C. §§1271 et seq.
- WILDERNESS AREAS	Wildernes Protection Act of 1964; 16 U.S.C. §§1131-1136
- COASTAL AREAS	Coastal Zones Management Act, 16 U.S.C. §§1451 et seq.
- WILDLIFE REFUGES	50 CFR Part 27.94
- SIGNIFICANT AGRICULTURAL LANDS	7 CFR Part 658
- WETLANDS	Section 404 of the Clean Water Act (CWA) of 1977; Presidential Executive Order 11990

proposed in a protected land (wetlands) settings.

2.4.1 Archaeological and Historic Places

The National Historic Preservation Act (NHPA) of 1966 (as amended in 16 U.S.C §§ 470 et. seq.) provides for the inventory and limited protection of valuable archaeological and historic places. NHPA establishes an Advisory Council on Historic Preservation and a National Register of Historic Places. The criteria for evaluating whether a location has historic significance and warrants inclusion on the National Register are as follows:

> "The quality of significance in American History, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and
>
> 1. that are associated with events that have made a significant contribution to the broad patterns of our history; and
> 2. that are associated with the lives of persons significant in our parts; or
> 3. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> 4. that have yielded, or may be likely to yield, information important in prehistory or history . . ."

The NHPA is enforceable through Section 106 (16 U.S.C. §§ 470(f)) which provides that, prior to the expenditure of any federal funds or the issuance of any federal license, the federal agency involved must take into account the effect of the project on any district, site, building, or structure that is included or is eligible for inclusion in the National

Register. The Advisory Council must also be afforded a chance to comment on the project through the "Section 106" process. The 106 review process is initiated through the state official designated as the "State Historic Preservation Officer." As a result of the 106 review, specific actions to mitigate effects may be required.

Since RCRA permits constitute a federal license, the 106 review process is required and must be implemented as recognized in 40 C.F.R. Section 270.3(b). The Regional Administrator is required to adopt measures, when feasible, to mitigate potential adverse effects of the facility upon properties listed or eligible for listing in the National Register. The procedures for carrying out the Section 106 process are detailed in 36 C.F.R. Part 800.

2.4.2 Endangered and Threatened Species

The Endangered Species Act of 1973 (16 U.S.C. §§ 1531-1543) provides protections for listed endangered and threatened species of animals and plants. The possible impacts of siting a land disposal facility in an endangered and threatened species habitat may include removal of critical habitat necessary for the survival of the species, restricting the movement of species, and degrading the environment near the facility. The Agency is obligated under Section 7 of the Endangered Species Act to ensure that permitted facilities are not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat (see 40 CFR Section 270.3(c)). Generally, the Agency interpretation of this obligation is to prohibit the siting of HWLTSD facilities within endangered or threatened species habitat. Permit writers are obliged to use the authority of this Act as grounds for permit denial in appropriate cases.

2.4.3 Parks, Monuments, and Scenic Rivers

National parks, monuments, preserves, seashores, parkways, battle field parks, and historic parks are protected under the Organic Act of 1916. The Organic Act established the National Park Service to administer the above listed lands with the objective of "conserving scenery and the natural historic objects and the wildlife therein ... by such means as will leave them umimpaired for future generations." Lands administered by the National Park Service are generally unacceptable for the location of HWLSD facilities. An exception is where the location of such a facility on these protected lands is authorized by Congress.

The Wild and Scenic Rivers Act (16 U.S.C §§ 1273 et. seq.) protects rivers and adjoining lands designated as wild and scenic by Congress. Section 7 of the Act prohibits the Regional Administrator from licensing the construction of any water resources project that would have a direct, adverse effect on the values for which a national wild and scenic river was established. Generally, the Agency interpretation of this obligation is to also discourage siting of HWLSD facilities in these riverine areas and adjoining lands to the extent that such facilities may impact these protected areas.

State and local parks, natural areas, scenic rivers, or recreational areas are likely to be protected under State statutory and/or regulatory authority. The permit writer is advised to consult with State and local authorities should a facility be located in or within close proximity to such areas.

2.4.4 Wilderness Areas

The Wilderness Protection Act of 1964 (16 U.S.C. §§ 1131-1136) designates wilderness areas within public lands that include National Parks, National Wildlife Refuges, National Forests, and Bureau of Land Management Lands. Designated wilderness areas cannot be used as sites for HWLTSD facilities or land treatment units without Congressional approval.

2.4.5 Coastal Areas

The Coastal Zone Management Act, 16 U.S.C. §§ 1451 et seq., requires that all Federal activities in coastal areas be consistent with appproved State Coastal Zone Management Programs to the maximum extent possible. If a facility permitting action by the Agency may affect a coastal zone area, the permit writer is required to assess the impact of the permitted facility on the coastal zone. If the facility significantly affects the coastal zone area and the State has an approved coastal zone management program, the permit writer is obliged to notify the appropriate State agency and recommend that the State examine the issues of siting in the coastal zone as appropriate under the State's program (see 40 CFR Section 6.302(d)).

2.4.6 Wildlife Refuges

National Wildlife Refuges are managed by the U.S. Fish and Wildlife Service for the primary purpose of developing a national program of wildlife and ecological conservation and rehabilitation. Refuges are established for the restoration, preservation, development, and management of wildlife and wildlife habitat, for the protection and preservation of endangered or threatened species and their habitat, and for the management of wildlife and natural habitats to obtain the maximum benefits from these resources. 50 CFR Part 27.94 specifically prohibits the draining or dumping of oil, acids, pesticide waste, poisons, or any other chemical waste into refuge areas, or otherwise, polluting any waters, waterholes, streams, or other areas within a refuge. A right-of-way permit can be retained for activities in a refuge provided that the activity is found to be compatible with the purpose of the refuge. The Agency does not consider a HWLTSD facility compatible with the purpose of a refuge; therefore, such locations are generally unacceptable for siting. Permit writers should also consider the degree to which proposed or expanded existing facilities may impact wildlife refuges that are within or in close proximity to facility property boundaries.

2.4.7 Significant Agricultural Lands

Until recently, only a few states provided regulations to protect agricultural lands by restricting the location of HWLSD facilities. The U.S. Department of Agriculture (USDA) Soil Conservation Service has promulgated a final rule under 7 CFR Part 658. The Farmland Protection Policy seeks to minimize the conversion of farmlands from agricultural to non-agricultural uses. The rule establishes criteria that Federal programs must consider and directs Federal programs to study alternative actions toward protecting farmland resources. Technical assistance is available from the USDA to Federal, State, and Local Agencies in assessing farmland protection issues. Permit writers should refer to the Federal Register, Volume 49, No. 130, pg. 27716 (July 5, 1984) and should coordinate with the USDA Soil Conservation Service for further information about the Farmland Protection Policy.

It has always been the general policy of the Agency to protect, to the extent possible, environmentally significant agricultural lands from conversion to uses which result in its loss as a food production resource or environmental resource. Before undertaking a permit action, the permit writer should consider whether there are significant agricultural lands in the area of the facility. If these areas are identified, direct and indirect effects of the facility on the land should be evaluated and adverse effects avoided or mitigated, to the extent possible. The Agency's policy regarding agricultural lands is described in a document entitled, "Policy to Protect Environmentally Significant Agricultural Lands" (September 8, 1978). Permit writers should contact their Regional NEPA Compliance Staff for further information regarding this Agency Policy (see 40 CFR Section 6.302(c)).

2.4.8 Wetlands

Wetlands are land areas where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils and to support the growth of hydrophytes (Cowardin, et al., 1979). Hydric soils are soils, that for a significant period of the growing season, have reducing conditions in the major part of the root zone and are saturated within 25 cm of the surface. The Agency has two principal concerns with regard to the location of land disposal facilities in wetlands. The first is the impact that new facility construction and operation will have upon the wetland environment. The second is the potential impact of accidental discharges of hazardous waste into the wetland environment.

HWLTSD facilities located in a wetland will result in the direct removal of wetland vegetation and may also alter wetland hydrology and degrade adjacent wetland areas through the disposal of spoil material and release of sediment.

The above concerns are addressed in two Federal permit programs: the NPDES and dredge and fill permit programs under Section 404 of the Clean Water Act, and by Presidential Executive Order 11990 for wetlands located on Federally-owned lands. The Section 404 dredge and fill permit program, administered by the U.S. Army Corps of Engineers, was established to prevent the discharge of dredge and fill materials into navigable waters of the United States and adjacent wetland where such discharge will have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas, wildlife areas, or recreational areas. Navigable waters, as interpreted by the courts for Section 404, mean all waters of the United States. However, not all wetlands as classified by Cowardin, et al. (1979) are covered by Section 404. The Corps of Engineers has issued general use permits for selected 404 wetlands, most notably, wetlands within the headwaters of watersheds (the upper 5 square miles of a stream watershed). In areas of potential wetland impacts, planned discharges from land disposal facilities would technically require a National Pollution Discharge Elimination System (NPDES) permit. This permit system has also been established through the Clean Water Act.

Although it does not carry the force of a law, Executive Order 11990 (May 1977) directs Federal agencies to avoid undertaking or providing assistance for new construction of projects located on federally-owned wetlands unless there is no practical alternative. In cases where there is no alternative site, all measures must be taken to minimize harm to the wetland.

The Agency previously determined that these existing programs adequately protected wetlands from adverse impacts of construction and siting of hazardous waste facilities and from adverse impacts due to discharges originating from these facilities. However, in the process of developing new location standards, the Agency will need to consider more closely that certain wetlands create specific hydrologic settings of ground-water flow that may provide conditions conducive to contamination migration when facility designs fail.

Since hazardous waste contamination may pose a much more significant threat than fill or dredged materials when introduced into a wetland setting, a preliminary assessment of wetland impacts should be made on a case-by-case basis.

In the event that preliminary review of the permit application shows that the facility is to be located on wetlands, the permit writer is advised to contact the Corps of Engineers District Office and EPA's Regional Wetlands Coordinator for verification and permitting consultation.

The Corps of Engineer District Office can provide a wetlands survey of the proposed site. The operational definition and identification of wetlands is not an exact science. The Corps of Engineers defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." (see 40 C.F.R. Section 230.3).

2.4.9 State and Local Considerations

In addition to the protected lands described above, state and local governments may also protect other sensitive environmental areas. Selected watersheds, for example, may be protected in order to ensure uncontaminated water supplies to a water supply reservoir. The means of protection often include restrictions on land use and may prohibit the siting of hazardous waste facilities. The permit writer should notify the appropriate State hazardous waste management agency regarding these and other sensitive locations and recommend that the State examine the siting issues as appropriate under State law.

2.5. VULNERABLE HYDROGEOLOGY

The vulnerable hydrogeology criteria is designed to protect Class II ground waters as established under the Agency's Ground-Water Protection Strategy (G-WPS). The 1984 amendments to RCRA require the Agency to develop guidance criteria that define a vulnerable hydrogeology by May 1986.

The Strategy outlines how various Agency program offices will operate, revise, and/or amend existing regulations to assure the protection of ground-water resources. Location guidance and future location standards for RCRA facilities are major elements toward meeting this goal.

The G-WPS keys regulatory activities to the following three classes of ground water, the class being largely dependent upon the use, value, and vulnerability of the resource:

I. Special Ground Water (Irreplaceable and Ecologically Vital)

II. Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses

III. Ground Water Not Considered a Potential Source of Drinking Water and of Limited Beneficial Use.

When implemented, the Ground-Water Protection Strategy will have far reaching implications for both new and existing RCRA facilities located over various classes of ground water. Table 2.5-1 indicates possible means of controlling facility siting for various ground-water classes. Ultimately, the Agency may ban through regulations the siting of new and existing HWLTSD facilities in vulnerable settings above Class I and Class II ground water. Until these rules are promulgated, proposals to site new facilities or expand existing

HWLTSD facilities in these locations should be discouraged.

A test for determining vulnerability of ground water to contamination from RCRA facilities will be presented in the RCRA Permit Writers' Location Guidance (Phase II). This test is being developed in cooperation with the Office of Ground-Water Protection which is characterizing vulnerability within a larger context. Currently under development, the Location Case Studies (Appendix E) to be included as part of Phase II will illustrate how the permit writer should determine whether or not the vulnerable hydrogeology criteria are met in a number of specific locational settings. In general, locations characterized by short time of travel of ground water along a ground-water flow line from the facility through the ground-water system are considered vulnerable settings.

At present there are no existing regulations to prohibit the siting of new or existing HWLTSD facilities located in vulnerable settings above Class I and Class II ground water. Until comprehensive location standards are promulgated, and after distribution of the Phase II RCRA Location Guidance Manual, permit writers should discourage siting of new facilities, expansions to existing facilities, and permitting of existing disposal facilities in these areas by relying upon one or more of the following:

1. requiring contingent corrective action programs and supporting evidence that such programs can be implemented in a timely fashion (see Section 3.3.2),
2. consider the ground-water classification in evaluating alternate concentration limits (ACLs) in the

TABLE 2.5-1 - GROUND-WATER CLASSIFICATION MATRIX
CURRENT RCRA OBLIGATIONS BASED ON EPA GROUND-WATER PROTECTION STRATEGY

Ground Water			Hazardous Waste Facilities	
Class	Usage	"Vulnerability"	New	Existing
I	Special	Vulnerable	Discourage siting via RCRA location guidance	Discourage siting via RCRA location guidance
			Ban via RCRA regulations	May ban via RCRA regulations
				Restrict/eliminate alternate concentration limit (ACL) demonstrations
				Clean up contamination beyond facility boundary
II	Current Use	Vulnerable	Discourage siting via RCRA location guidance	No Change
			May ban via RCRA regulations	
		Non-vulnerable	No Change	No Change
	Potential Use	Vulnerable	Allow contaminant clean-up	Allow contaminant clean-up
		Non-vulnerable	Allow contaminant clean-up	Allow contaminant clean-up
III	No Potential As Usable Water Source	N/A	Less stringent clean-up	Less stringent clean-up
			Waivers via ACLs	Waivers via ACLs

facility's ground-water protection standard (see Section 3.3.1), and

3. restrict the use of exclusions of Appendix VIII constituents from ground-water monitoring (see Section 3.3.1).

The following subsections describe the three ground-water classes and regulatory considerations discussed in the G-WPS. Various terms in quotes will be defined in guidance documents developed by the Agency's Office of Ground-Water Protection. Various methods for determining whether a facility is located in a vulnerable hydrogeologic setting are currently being developed. These methods for evaluating site vulnerability will be made available to the permit writer in the Phase II RCRA Location Guidance.

Classification and delineation of ground water is currently under way in many States. Until the issue of equivalency between State and Federal classification systems is resolved, the classification of the uppermost aquifer will be determined on a case-by-case basis through the RCRA permitting process. Facility locations in vulnerable settings above Class I and Class II ground-water systems will be considered unacceptable.

2.5.1 Class I Ground Water

Class I ground water is defined on the basis of one of the following two factors:

1. "Irreplaceable source of drinking water." These include ground water located in areas where there is no alternative source of drinking water (islands, peninsulas, isolated ground water over bedrock) or an insufficient alternative source for a substantial population; or

2. "Ecologically vital," in that the ground water contributes to maintaining either the base flow or water level for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat (e.g., those associated with wetlands that are habitats for unique species of flora and fauna or endangered species).

The siting of new HWLTSD facilities and permitting of existing HWLTSD facilities in vulnerable settings above Class I ground water should be discouraged. The RCRA Part 264 regulations will eventually incorporate location standards that ban new HWLTSD facilities that pose a risk to Class I ground water. These regulations may also force phase-out of existing facilities in these locations. Where contamination has occurred within the boundary of existing facilities, ground-water cleanup will be required to the appropriate level, either to drinking water standards or background levels during the active life of the unit. Issuance of alternate concentration limits (ACLs) will not normally be appropriate in these areas.

2.5.2 Class II Ground Water

Class II encompasses all other ground water "currently used" or "potentially available" for drinking water and other beneficial use, whether or not it is particularly vulnerable to contamination. This class comprises the majority of usable ground water in the United States. New HWLTSD facilities in vulnerable settings above currently-used Class II ground water are to be discouraged until location standards are promulgated that may ban siting of such facilities in these settings. At closure, certain existing facilities in extremely vulnerable locations may need to close under current closure requirements for storage facilities where waste must be removed from the unit. Existing facilities will be subject to current ground-water protection standards with cleanup to drinking water standards or background levels required as appropriate during the active life.

For both new and existing facilities in non-vulnerable settings above Class II ground water, the requirements will differ based on the specific current or potential use of the ground water. Where ground water exists in a non-vulnerable setting and is currently used for drinking water or other beneficial purposes, new and existing facilities will be subject to current RCRA ground-water protection requirements, with cleanup to drinking water standards, background levels, or alternate concentration limits (ACLs) as appropriate. For sites which can impact potential sources of ground water, the same policy will generally apply. However, for these ground waters, the Agency may allow various plume management options that take into account such factors as the probability of potential ground-water use and the availability of cost-effective methods to ensure water quality at the point of use.

Cleanup policies for these categories of ground water will also vary, depending upon the use, value, and vulnerability of the ground water. The most stringent requirements will apply where contamination is caused by a hazardous waste facility. If the ground water is defined as having a current use, the general policy is to eliminate the source of contamination and treat contaminated ground water to the highest technically feasible level required to protect human health and the environment. The Agency recognizes that there are circumstances which must be approached on a case-by-case basis, in which mitigating the source of contamination and managing the plume will be the most reasonable course of action. The Agency plans to consider this approach when such circumstances arise in setting alternate concentration limits (ACLs) and approval of corrective action plans.

2.5.3 Class III Ground Water

Ground water that is saline or otherwise contaminated beyond levels which would allow for drinking or "other beneficial use" is considered Class III ground water if it is "hydrogeologically isolated" as defined in the classification guidance being developed under the Ground-Water Protection Strategy. This includes ground water with a Total Dissolved Solids (TDS) level over 10,000 mg/l or that is so contaminated by naturally-occurring contaminants or by human activity (unrelated to a specific hazardous waste land disposal site) that ground water cannot be cleaned up using methods generally employed in public water system treatment.

The Agency will continue to require facility design and operating standards for Class III ground water to ensure no migration to Class I and Class II ground water, and to prevent a discharge to surface water that could adversely affect human health or the environment. Since the ground water is not usable, the issuance of alternate concentration limits will often be appropriate thus minimizing the need for corrective action for additional contamination resulting from facilities over Class III ground water.

3.0 EXISTING REGULATIONS TO EVALUATE LOCATIONS

Various existing regulations may be relied upon as a basis for making permit decisions about a RCRA facility location and whether or not it is appropriate for safe and proper siting. The purpose of this section is to provide the permit writer with a full citation of RCRA facility performance standards and Federal Statutes that implicitly involve hydrogeologic factors for addressing acceptable locations. Table 3.0-1 is a summary of location criteria and applicable existing RCRA regulations. The permit writer should consider separately each criterion for which a facility location will be tested by examining whether or not the facility is in compliance with referenced existing regulations.

3.1 EXISTING RCRA LOCATION STANDARDS

Two standards for the location of hazardous waste land treatment, storage, and disposal (HWLTSD) facilities -- seismic restrictions (40 CFR Part 264.18(a)) and floodplain standards (40 CFR Part 264.18(b)) -- have been promulgated. Guidance for determining compliance with these location standards is available in an EPA document entitled, "Permit Applicants' Guidance Manual for the General Facility Standards of 40 CFR Part 264" (SW-968, October 1983).

3.1.1 Seismic Standard

The seismic standard prohibits siting of portions of new HWLTSD facilities within 61 meters (200 feet) of a fault known to be active during Holocene time (a period occurring during the last 10,000 years). The intent of this standard is to ban

TABLE 3.0-1: CROSS-REFERENCE OF LOCATION CRITERIA AND
AND APPLICABLE EXISTING RCRA STANDARDS

CRITERIA FOR LOCATION ACCEPTABILITY	RCRA Part 264 Standards						
	General Part B Requirements	Seismic Standard	Floodplain Standard	Monitoring Requirements	Liner Foundation	Closure Standard	Dike Integrity
Manual Section	2.1	3.1	3.1	3.2.1	3.2.2	3.2.3	3.2.4
Site Characterization	S,D	S,D		S,D	S,D	S,D	
High Hazard and Unstable Terrain							
a. Flood-prone areas			S,D				
b. Seismic impact zones		S,D			S,D	D	S,D
c. Volcanic impact zones					S,D	D	S,D
d. Landslide-susceptible areas					S,D	D	S,D
e. Subsidence-prone areas		S,D		S,D	S,D	D	S,D
f. Weak and unstable soils					S,D	D	S,D
Ability to Monitor				S,D			
Groundwater Vulnerability			(No regulatory basis at present to deny permit)				

APPLICABLE FACILITY TYPES
S = Storage Unit
D = Disposal Unit

new facilities in locations on or near faults that are likely to experience displacement in the future. Geologic evidence indicates that faults which have moved in recent times are more likely to move in the future. "Fault" is defined to include the various forms of faults (i.e., main, branch, or secondary) that may not result in surface expression. The 61 meter setback was based on available data indicating that most ground deformation due to fault movement occurs within 61 meters to 91 meters (200 feet to 300 feet) of the active fault. The available data also indicated that deformation generally decreases rapidly with distance from the fault. Regulatory language and definitions from 40 CFR Part 264.18. (a) are provided as follows:

(a) Seismic considerations. (1) Portions of new facilities where treatment, storage, or disposal of hazardous waste will be conducted must not be located within 61 meters (200 feet) of a fault which has had displacement in Holocene time.

(2) As used in paragraph (a)(1) of this Section:

(i) "Fault" means a fracture along which rocks on one side have been displaced with respect to those on the other side.

(ii) "Displacement" means the relative movement of any two sides of a fault measured in any direction.

(iii) "Holocene" means the most recent epoch of the Quaternary period, extending from the end of the Pleistocene to the present (a period of 10,000 years).

NOTE: Procedures for demonstrating compliance with

> this standard in Part B of the permit application are specified in §270.14(b)(11). Facilities that are located in political jurisdictions other than those listed in Appendix VI of Part 264, are assumed to be in compliance with this requirement.

The seismic restriction does not explicitly specify all of the concerns inherent in the location of HWLTSD facilities in areas susceptible to seismic impacts. As presented in Section 2.0, ground motion effects such as faulting or earth fissures resulting from nonseismic events, e.g., land subsidence due to fluid withdrawal, are also of major concern. The major omission from the current standard is a means of accounting for these ground motion effects both within and beyond 61 meters (200 feet) of a fault. The existing standard solely addresses fault deformation and displacement impacts. Ground motion may also cause ground failures outside of the 61 meters (200 feet) distance that may impact a facility including landsliding, liquefaction, settlement and lurching, or accelerated soil creep. The potential for seismically-induced ground failure is related to specific geologic, hydrologic, and pedologic characteristics of each location evaluated. Ground failure-prone locations may be considered high hazard terrains which overlap, to some extent, with seismic impact zones, landslide-susceptible areas, and weak and unstable soils under certain conditions.

The Agency may consider making revisions to current RCRA seismic restrictions to more explicitly address the concerns outlined above. The permit writer is referred to other existing regulations presented in Section 3.2 for locations suspected of having a susceptibility to ground motion-induced ground failures.

3.1.2 Floodplain Standard

The floodplain standard prohibits the location of HWLTSD facilities within the 100-year floodplain unless one of the following three criteria are met: a) the facility is designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood, b) the applicant can demonstrate that the waste can be safely removed before flood waters can reach the facility, or c) for existing HWLTSD facilities, the applicant can show no adverse effects on human health or the environment will result if a washout occurs. The 100-year flood was selected as the basis for this standard because it is the most widely used parameter in other Federal programs and has been operationally defined in a large number of communities.

In the January 12, 1981 Federal Register, the Agency chose not to adopt two other standards related to flooding and floodplains. A wetlands standard under RCRA is currently not in effect since existing programs administered under the NPDES requirements and Section 404 of the Clean Water Act (CWA) has been relied upon to adequately protect wetlands from any adverse impacts of facility construction and siting. The permit writer should coordinate with the appropriate Federal Agency to be sure that the facility owner or operator complies with existing wetland protection requirements and to determine a course of action if the owner or operator is not in compliance. The permit writer should determine whether the owner or operator is also seeking approval of other Federal permits before issuing a RCRA facility permit (See Section 2.4.4).

A "Coastal High Hazard" restriction to prohibit facilities from siting in such areas may not be widely understood to be included as part of the RCRA floodplain standards. However, coastal high hazard areas are generally located within the 100-year floodplain and, therefore, are locations that are also protected under the floodplain standard. These areas are subject not only to flooding but also to wave action during coastal storms. The impacts of wave action should be considered to the extent that information about the design, construction, maintenance, and operation of a facility to protect against flooding and washout can be required to support the permit application. Two types of coastal high hazard areas, barrier islands and eroding shorelines, may not be able to satisfy existing standards for liner foundation stability. The permit writer reviewing a permit application for an existing, proposed, or expanding facility in a barrier island setting or a shoreline subject to erosion is referred to Sections 3.2.2 and 3.2.4 of this guidance manual. Such locations should also be subject to the supplementary restrictions outlined in Section 3.3.

The floodplain standard and accompanying definitions under 40 CFR Part 264.18(b) are as follows:

(b) Floodplains.

(1) A facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year

flood, unless the owner or operator can demonstrate to the Regional Administrator's satisfaction that:

(i) Procedures are in effect which will cause the waste to be removed safely, before flood waters can reach the facility, to a location where the waste will not be vulnerable to flood waters; or

(ii) For existing surface impoundments, waste piles, land treatment units, and landfills, no adverse effects on human health or the environment will result if washout occurs, considering:

(A) The volume and physical and chemical characteristics of the waste in the facility;

(B) The concentration of hazardous constituents that would potentially affect surface waters as a result of washout;

(C) The impact of such concentrations on the current or potential uses of water and water quality standards established for the affected surface waters; and

(D) The impact of hazardous constituents on the sediments of affected surface waters or the soils of the 100-year floodplain that could result from washout.

(2) As used in paragraph (b)(1) of this Section:

(i) "100-year floodplain" means any land area which is subject to a one percent or greater chance of flooding in any given year from any source.

(ii) "Washout" means the movement of hazardous waste from the active portion of the facility as a result of flooding.

(iii) "100-year flood" means a flood that has a one percent chance of being equalled or exceeded in any given year.

3.1.2.1 Wetland Executive Order

Besides the RCRA 100-year floodplain standard, the permit writer should consider prevention of impacts to wetlands under Executive Order 11990 (see 40 C.F.R. §§ 6.302(a)) when evaluating facilities located on federally-owned property. Wetlands are commonly found in areas adjacent to floodplain locations. Executive Order 11990 directs Federal Agencies to prevent long- and short-term adverse impacts associated with the destruction or modification of wetlands located on federally-owned property and to avoid direct or indirect support of new construction in such wetlands. Wherever there is a practical alternative, the Agency is obligated to minimize the destruction, loss, or degradation of wetlands when considering issuance of a RCRA permit. The Agency must consider how a facility may effect both the survival and environmental quality of wetlands. Among these factors are:

a. public health, safety, and welfare including: water supply, quality, recharge, and discharge; pollution; flood and storm hazards; and sediment and erosion;

b. maintenance of natural systems, including conservation and long-term productivity of existing flora and fauna; species and habitat diversity and stability; hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

c. other uses of wetlands in the public interest including recreational, scientific, and cultural uses.

3.2 EXISTING RCRA DESIGN AND OPERATING STANDARDS

In addition to the seismic and floodplain standards, certain RCRA regulations under 40 CFR Part 264 serve as the basis for denying a permit to owners or operators of HWLTSD facilities in locations characterized by poor hydrogeologic conditions. Most of these regulations may not have been previously recognized by permit writers as a basis for denying a permit in cases where facilities are located in unacceptable settings. By their nature, certain specific design and operating performance standards require hydrologic and geologic conditions that provide locational settings conducive to safe and proper siting of facilities.

Four existing RCRA regulations that have inherent hydrologic and geologic factors are listed below and are further described in subsequent sections. These are:

- Monitoring Requirements
- Liner Foundation Requirements
- Closure Performance Standard
- Impoundment Dike Foundation Requirement

As currently written, the RCRA regulations allow the owner or operator to demonstrate that poor geologic and hydrologic conditions at the facility location may be improved through proper unit design and operation. The permit writer is responsible for determining whether the owner or operator has made a satisfactory demonstration.

3.2.1 Monitoring Requirements

General ground-water monitoring requirements under 40 CFR Part 264 Subpart F entitled, Ground-Water Protection Standards, are found in Sections 264.92 and 264.97. The components of these sections that can be used to evaluate locational acceptability are provided below:

- Pursuant to Section 264.92 (Ground-Water Protection Standard), the owner or operator must comply with conditions specified in the facility permit that are designed to ensure that hazardous constituents as defined in Section 264.93 entering the ground water from a regulated unit do not exceed the concentration limits established under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance established under Section 264.95 during the compliance period as defined in Section 264.96.
- Pursuant to Section 264.97 (General Ground-Water Monitoring Requirements), the owner or operator must comply with the following requirements for any ground-water monitoring program developed to satisfy §264.98, §264.99, or §264.100:
  - (a) The ground-water monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths, to yield ground-water samples from the uppermost aquifer that:
  - (1) Represent the quality of background water that has not been affected by leakage from a regulated unit; and
  - (2) Represent the quality of ground water passing the point of compliance.

* * *

(g) Where appropriate, the ground-water monitoring program must establish background ground-water quality for each of the hazardous constituents or monitoring parameters or constituents specified in the permit.

(1) In the detection monitoring program under §264.98, background ground-water quality for a monitoring parameter or constituent must be based on data from quarterly sampling of wells upgradient from the waste management area for one year.

(2) In the compliance monitoring program under §264.99, background ground-water quality for a hazardous constituent must be based on data from upgradient wells that:

(i) Is available before the permit is issued;

(ii) Accounts for measurement errors in sampling and analysis;

(iii) Accounts, to the extent feasible, for seasonal fluctuations in background ground-water quality if such fluctuations are expected to affect the concentration of the hazardous constituent.

(3) Background quality may be based on sampling of wells that are not upgradient from the waste management area where:

(i) Hydrogeologic conditions do not allow the owner or operator to determine what wells are upgradient; or

(ii) Sampling at other wells will provide an indication of background ground-water quality that is as representative or more representative than that provided by the upgradient wells.

In summary, the monitoring well system must yield ground-water samples from the uppermost aquifer that represent both the quality of background water as per Section 264.97 (a)(1) and the quality of ground water passing the point of compliance as per Section 264.97 (a)(2). Background wells are preferably located upgradient but are not required to be upgradient under special circumstances as outlined in Section 2.3. Where Section 264.92 and Subsections 264.97 (a)(1) and (a)(2) cannot be met, a permit can be denied. An inability to install wells at sites around the waste management area that satisfy the criteria is one such situation that is grounds for permit denial.

Further provisions of Subpart F and permit information requirements of 40 CFR Part 270.14(c) require the owner or operator to "determine the ground-water flow rate and direction in the uppermost aquifer." Both the detection monitoring program (Part 264.98(e)) and the compliance monitoring program (Part 264.99(e)) specify the following:

> (e) The owner or operator must determine the ground-water flow rate and direction in the uppermost aquifer at least annually.

The same provision applies to monitoring of corrective actions under Part 264.100(d). 40 CFR Part 270.14(c)(2) requires the owner or operator to do the following:

> (2) Identify the uppermost aquifer and aquifers hydraulically interconnected beneath the facility

property, including ground-water flow direction and rate, and the basis for such identification (i.e., the information obtained from hydrogeologic investigations of the facility area).

Where the ground-water flow rate and direction is not identified and the owner or operator cannot correct the deficiency in the permit application after being served a notice to to this effect, a permit can be denied on the grounds that monitoring standards cited above cannot be met. Furthermore, a basis for permit denial exists in cases where hydrogeologic conditions at the facility location are so complex that a determination of ground-water flow direction and flow rate are not possible (for example, karst terrains or fractured bedrock).

Certain existing HWLTSD facilities may be exempt from ground-water monitoring requirements as set forth in 40 CFR Part 264.90.

3.2.2 Liner Foundation Requirements

Design and operating standards for waste piles, landfills, and surface impoundments require a liner (see Parts 264.251(a), 264.301(a), and 264.221(a), respectively) that is designed, constructed, and installed to prevent any migration of waste out of the unit to the adjacent subsurface soil, ground water, or surface water at any time during the active life (including the closure period) of the facility. Liner foundation requirements are identical for each type of unit. Existing portions of existing facilities are exempt from the liner standard. The standard includes the following element:

> The liner must be placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift. (See Section 264.221(a)(2), surface impoundment, Section 264.251(a)(1)(ii), waste piles, and Section 264.301(a)(1)(ii), landfills.)

The following sensitive areas will generally possess hydrologic, geologic, and pedologic characteristics that may create conditions at the facility site that could result in an inability to comply with the liner foundation standard:

- landslide-susceptible areas
- subsidence-prone areas
- karst terrains
- weak and unstable soils

The permit writer should require the applicant to submit a geotechnical engineering report that demonstrates compliance with the liner foundation requirement and demonstrates, based on the history of the location's stability, the likelihood of impacts at the site due to mass movement, subsidence, and weak soils. The report requirement is included under the general ground-water information gathering authority in 40 CFR Part 270.14(c) plus the authority for specific units under 40 CFR Part 270.17(b) (surface impoundments), 40 CFR Part 270.19(c) (waste piles), and 40 CFR Part 270.21(b) (landfills).

The permit writer's case for permit denial may not be based on a notion that a mere possibility of unstable foundation conditions exist at the site or may exist at the site in the future. If a facility is located in an area where subsidence is actually occurring, the applicant must demonstrate that engineering efforts to improve the foundation of the liner will ensure compliance with the standard. Where there is a sound likelihood of a future landslide or subsidence event, the applicant must demonstrate how the proposed design will prevent failure in the event of a landslide or subsidence. The permit writer must critically evaluate these demonstrations, seeking expert assistance as necessary, before permit issuance. If the demonstration shows that conditions at the site are not adequate for the installation of the liner, the permit must be denied.

3.2.3 Closure Standards

At closure, owners or operators of landfills and surface impoundments, where waste is not to be removed or decontaminated, are required to cover the unit with a final cover designed and constructed to:

(1) provide long-term minimization of migration of liquids through the closed unit,

(2) function with minimum maintenance,

(3) promote drainage and minimize erosion or abrasion of the cover,

(4) accommodate settling and subsidence so that the integrity of the cover is maintained, and

(5) have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

(see Section 264.310(a) (landfills) and Section 264.228(a)(2)(iii) for surface impoundments)). The closure standards apply to all units used for disposal independent of the requirements under the liner foundation standards (see Section 3.2.2).

High hazard and unstable terrains may be subject to forces and natural events that pose conditions where cover failure and escape of hazardous waste to ground or surface waters or the atmosphere from a unit are likely to occur in these locations during the post closure period, as well as the active life of the facility. Facilities proposed or located in high hazard and unstable terrains may be subject to local hydrogeologic conditions that could make compliance with the closure standard difficult. Permits for new facilities, expansion of existing units, and existing facilities should be denied when an owner or operator cannot demonstrate an ability to comply with RCRA performance standards.

The applicant must submit an engineering report that provides the following: (a) a description of how the cover standards will be complied with, (b) a site characterization that delineates the specific site and local conditions that create high hazard and unstable conditions, and (c) the probability that the facility will be impacted by such conditions. The permit writer is authorized to require this report through Section 270.17(g) for surface impoundments and Section 270.21(e) for landfills. In submitting this report, the permit applicant must demonstrate how the proposed closure design will prevent the migration of waste from the unit. The permit writer must critically evaluate this demonstration, seeking expert assistance as necessary, before permit issuance. If the demonstration is not adequate, the proposed closure design should not be approved.

3.2.4 Dike Integrity Standard

Although the dike integrity requirement applies to all surface impoundments used to treat, store, or dispose of hazardous waste, the requirement is particularly important in the case of existing storage impoundments because neither liner nor cover standards apply to these units.

The design and operating requirements for surface impoundments specify the following:

> A surface impoundment must have dikes that are designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes. In ensuring structural integrity, it must not be presumed that the liner system will function without leakage during the active life of the unit.
>
> (See 40 CFR Part 264.221(d)).

High hazard and unstable terrains are subject to forces and natural events that may impair the structural integrity of dikes. Seismic ground motion due to earthquakes or volcanic activity combined with weak soil conditions in landslide-prone locations are 'worst case' scenarios. A permit should be denied if the dike system cannot provide an adequate factor of safety under various conditions that exist or are likely to occur in these sensitive locations. For example, dikes must be safe and stable during all phases of construction and operation of a surface impoundment. Of particular interest is the stability of the dike to preclude failures during (1) the end of construction, (2) steady-state seepage, (3) rapid drawdown, and (4) seismic and volcanic events.

Elements to be considered in the design and evaluation of dikes for stability and addressed in the application include foundation conditions, embankment materials, and liner type, all of which are part of the dike system.

Foundations may present problems where they contain adversely oriented joints, slickensided or fissured material, faults, seams of soft materials, or weak layers. Liquefaction of loose, saturated sands and silts may occur under conditions of cyclic to shear deformation by earthquake shocks (or nearby heavy construction activity).

Slope failure of the dike system, in which a portion of the dike or of an embankment and foundation moves by sliding or rotating relative to the remainder of the mass, is the major consideration in stability analyses. Minimum factors of safety should be reported from slope stability analyses conducted for the following failure modes:

- End of construction (proposed dikes only)
- Steady-state seepage
- Rapid drawdown
- Seismic conditions (when in a sensitive area that is rated as earthquake-prone; see zones 2 and 3 in Figure 2.2.2-1 on Seismic Zoning in the United States)

No single, specific, minimum Factor of Safety for slope stability has been recommended. An acceptable Factor of Safety depends on the confidence with which soil data are known and the consequences of a dike failure. (see Section 5.2.4 on "Structural Integrity of Dikes" in the Permit Applicants' Guidance Manual for Hazardous Waste Land Treatment, Storage, and Disposal Facilities, Final Draft, May 1984 (EPA 530-SW-84-004). This manual is available for $13.00 from for $13.00 from the Government Printing Office (GPO) under stock number 055-000-00240-1 by calling GPO at (202) 783-3238).

3.3 SUPPLEMENTAL REGULATORY PROVISIONS FOR PERMIT APPROVAL

Permits for hazardous waste land storage and disposal (HWLSD) facilities proposed or sited in unacceptable locations can include supplemental conditions under RCRA rules as additional safeguards to compensate for location limitations. Table 3.3-1 lists the applicability of various supplemental RCRA provisions to each of the criteria for location acceptability. Permit writers should investigate the feasibility of using supplemental provisions for facility locations where a permit denial based on the requirements presented in Section 3.2 is inappropriate. Supplemental provisions may be used in order to account for the added risk of an unacceptable location. Supplemental provisions are as follows:

- restricting considerations of alternate concentration limits (ACLs) in post-closure permits and of exclusions of Appendix VIII constituents from monitoring,
- requiring contingent corrective action programs,
- extending the post-closure care period.

3.3.1 Alternate Concentration Limit (ACL) and Appendix VIII Exclusion Restrictions

Regional Administrators are authorized to establish an alternate concentration limit (ACL) for hazardous constituents in the ground-water protection standard (40 CFR Part 264.94(b)). In establishing the ACL, the Regional Administrator must consider a number of factors including:

(1) Potential adverse effects on ground-water quality, considering the following:

(ii) The hydrogeologic characteristics of the facility and surrounding land;

TABLE 3.3-1: SUPPLEMENTAL RCRA PROVISIONS USEFUL AS A BASIS FOR PERMITTING

CRITERIA FOR LOCATION ACCEPTABILITY	ACL Restrictions and Appendix VIII Exclusions in Post-Closure Permits	Contingent Corrective Action	Extended Post-Closure Care Period	
Manual Section	3.3.1	3.3.2	3.3.3	Comments
Site Characterization				Supplemental RCRA provisions listed are found in the following sections of 40 CFR Part 264, respectively:
High Hazard and Unstable Terrains				
a. Flood prone areas	D		D	
b. Seismic impact zones				§264.94(b) and (c); §264.93(b) §264.91(b) §264.117(a)(2)(ii)
c. Volcanic impact zones		S,D	D	
d. Landslide susceptible areas		S,D	D	
e. Subsidence prone areas		S,D	D	
f. Weak and unstable soils		S,D	D	
Ability to Monitor	S,D	S,D	S,D	

APPLICABLE FACILITY TYPES
S = Storage Unit
D = Disposal Unit

(iii) The quantity of ground water and the direction of ground-water flow;

(iv) The proximity and withdrawal rates of ground-water users;

(v) The current and potential usages of ground water in the area;

(vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality.

(2) Potential adverse effects on hydraulically-connected surface-water quality, considering the following:

(ii) The hydrogeologic characteristics of the facility and surrounding land;

(iii) The quantity and quality of ground water, and the direction of ground-water flow as it affects surface waters;

(iv) The patterns of rainfall in the region;

(v) The proximity of the regulated unit to surface waters;

(vi) The current and potential usages of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface-water quality; and,

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents.

The Regional Administrator must consider "any identification of underground sources of drinking water and exempted aquifers made under §144.8 of this chapter" in making decisions about the use of ground water in the area around the facility (see Part 264.94(c)).

HWLTSD facilities that do not meet the design, operation, and location standards where the first four criteria for location acceptability are factors in their noncompliance should not be issued operating permits under existing RCRA regulations. These facilities must close any existing regulated units and obtain a post-closure permit that applies the Part 264 Subpart F Standards. It is unlikely that the issuance of ACLs would be appropriate at these facilities because it would already have been demonstrated that the facility location presents problems that inhibit a favorable demonstration under the factors listed in §264.94(b).

Facilities located above Class I ground water and above Class II ground water in vulnerable locations may pose a distinct threat to the ground-water quality as well as to hydraulically-connected surface-water quality. The Agency may consider changes to the current RCRA standards which would eliminate the opportunity to make ACL demonstrations for facilities in these locations.

The Regional Administrator may specify the hazardous constituents to which the ground-water protection standard under Part 264.92 applies in a particular facility permit. Constituents to be monitored are to be selected from the Appendix VIII list in Part 264. The Regional Administrator may exclude an Appendix VIII constituent from the list of hazardous constituents specified in the permit if the applicant can demonstrate that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment (see 40 CFR §264.93(b)). In deciding whether to grant a monitoring exemption for a hazardous constituent, the Regional Administrator must consider the same factors as are required to grant an ACL (see Section 3.3.1). Existing HWLTSD facilities that are sited in locations that do not meet one or more of the criteria for an acceptable location will, in many cases, fail to qualify for an exclusion of Appendix VIII constituents. Facilities located in vulnerable settings above Class I or Class II ground water especially, pose a distinct threat to ground-water quality and to hydraulicallyconnected surface-water quality. Regional Administrators should consider carefully the use of an exclusion of Appendix VIII constituents from monitoring requirements at facilities sited in locations that do not meet all criteria of acceptability outlined in the Location Guidance Manual.

3.3.2 Combined Ground-Water Protection Programs in RCRA Permits

Provisions in the ground-water protection standard under 40 CFR § 264.91(b) authorize Regional Administrators to combine more than one ground-water protection program in a facility permit. The Regional Administrator may combine detection monitoring, compliance monitoring, and/or corrective action programs as part of the facility permit application as necessary to protect human health and the environment. In deciding whether to invoke this authority, the permit writer should consider the potential adverse effects on human health and the environment which might occur during the administrative period necessary to revise the permit to establish a different ground-water protection program. Existing facilities sited in areas where the local hydrologic and geologic setting creates a sensitive location present appropriate circumstances for requiring a combined program.

Requiring a contingent corrective action program, for example, will eliminate the added time needed for administrative processing and permit modification preparation prior to implementation of corrective action. In this way, timely corrective action is better assured when a facility failure occurs. The difficulty with this approach is that the Agency cannot require the applicant to submit the information necessary for a contingent corrective action program unless there has been a release of a hazardous constituent in excess of ground-water protection standards (see 40 CFR §270(14)(c)(8)). The permit writer can gather the necessary information independently of the permit application process using other information gathering authorities such as Sections 3007 and 3013.

Assuming that the necessary information can be obtained and permit denial is not appropriate, the permit writer should consider requiring contingent corrective action plans in the permit at existing HWLSD facilities located in a sensitive area or in vulnerable settings above Class I or Class II ground water. The failure of a facility due to a likely natural or man-induced event in a sensitive location, or the rapid migration of contaminants following a failure event in a vulnerable setting over Class I and II ground waters will generally require immediate corrective action to protect human health and the environment.

Combining corrective action provisions with detection and/or compliance monitoring programs may be difficult. In many cases, it may not be possible to include a full, comprehensive corrective action plan in a permit due to the complexity of site-specific hydrogeologic characteristics. However, when the situation warrants, it may be possible to develop an interim program which would include general steps to be taken to protect human health and the environment, and which would require the collection of additional information on the specific remedy needed. The new information acquired pursuant to this interim program would then provide the basis for a permit modification (pursuant to §270.41 (a)(2)) to establish a more detailed corrective action program.

Special attention should be taken to assure that the corrective action proposed by the permit applicant is appropriate for the unstable conditions that exist at each sensitive location. The permit writer should be convinced that the corrective action will work to prevent additional adverse impacts that may result due to local hydrogeologic conditions. The permit writer may require a simulation using a numerical or analytical model calibrated to specific site conditions. The permit writer should consider requiring a combined ground-water protection program for existing facilities that seek a permit to operate in certain sensitive locations (assuming that permit denial has been determined to be inappropriate). The Agency may change the current RCRA standards to strengthen the combined permit approach.

3.3.3 Extended Post-Closure Care Period

Facility post-closure care must continue for thirty years after the date of completing closure as specified in 40 CFR Part 264.117. The Regional Administrator may "extend the post-closure care period if he or she finds that the extended period is necessary to protect human health and the environment" (see 40 CFR Section 264.117(a)(2)(ii)). Existing land disposal facilities located in sensitive areas where containment structures are likely to fail or in vulnerable settings above Class I or Class II ground water may require an extension of the post-closure period to prevent significant adverse impacts from occurring when the facility fails. The permit writer may be able to determine an appropriate timeframe over which the post-closure care period should be extended based upon site hydrologic and geologic conditions. The ability of the location to prevent rapid waste migration when failure occurs may play a part in determining an appropriate closure period extension. The Phase II location guidance will provide the permit writer with various methods for making a determination.

In certain cases, ultimate removal of waste at closure for existing land disposal units sited in either high hazard and unstable terrains or in vulnerable settings above Class I or Class II ground water may be the only viable alternative in preventing adverse impacts from occurring during the post-closure period. Facility owners or operators having land disposal units in these locations may eventually need to remove waste at closure.

3.4 CONSIDERATIONS UNDER THE IMMINENT HAZARD PROVISION OF RCRA AND OTHER PROVISIONS OF THE RCRA AMENDMENTS OF 1984

Section 7003 of RCRA provides, in part that:

> "Notwithstanding any other provision of this Act, upon receipt of evidence that the handling, storage, treatment, transportation or disposal of any solid waste or hazardous waste may present an imminent and substantial endangerment to health or the environment, the Administrator may bring suit on behalf of the United States in the appropriate district court to immediately restrain any person contributing to such handling, storage, treatment, transportation or disposal to stop such handling, storage, treatment, transportation, or disposal or to take such other action as may be necessary...."

This provision gives EPA broad authority to issue administrative orders in any situation where the presence of solid waste or hazardous waste may present an imminent and substantial endangerment to health or the environment. The terms "imminent and substantial endangerment" as used in this Section have been judicially defined several times to mean that evidence of actual harm is not required, but only the risk of harm.

One must judge the risk or likelihood of the harm by examining the factual circumstances, including, but not limited to: 1) nature and amount of the hazardous substance; 2) the potential for exposure of humans or the environment to the substance; and 3) the known or suspected effect of the substance on humans or that part of the environment subject to exposure to the substance.

Guidance on the applicability and use of §7003 Administrative Orders has been distributed by the Office of Enforcement and Compliance Monitoring (OECM). The OECM guidance is a revision of a September, 1981 Agency document issued by the Office of

Waste Programs Enforcement. The following discussion is intended to supplement the OECM guidance on §7003, and not to be read in lieu of it. Use of Section 7003 authority and various other authorities under the RCRA amendments of 1984 may be appropriate under several situations encountered in evaluating permit applications under Part 264 and associated location considerations. The concepts presented in this section of the Phase I manual represent situations that may be unique to permit application evaluation and the location criteria.

3.4.1 Considerations Prior to Permit Issuance

Under the 1984 RCRA amendments, the Agency has new authority in Section 3008(h) (Interim Status Corrective Action Orders) that may be more appropriate than the current imminent hazard provision when imminent and substantial endangerment is identified at an interim status RCRA facility. This authority is extremely broad and enables the Agency to initiate a corrective action program upon detection of a release of a hazardous waste or hazardous waste constituent from a solid waste management unit. Additional guidance will be forthcoming in early 1985 on various situations and conditions when each of the several authorities now offered to the permit writer are most appropriate.

Situations that may pose an imminent and substantial endangerment that could be discovered during permit application evaluation include the following:

1) An aspect of an existing facility design or operation provides an inadequate factor of safety, and there is a risk of massive failure.

In particular, if a surface impoundment dike has a factor of safety, under steady state conditions, of less than or equal to 1.3, an imminent hazard may exist. A similar factor of safety under a rapid drawdown analysis poses an imminent hazard if there is any reason to anticipate a complete or substantial emptying of the impoundment prior to permit issuance. Similarly, if it can be shown that the mass of the waste management unit (i.e., waste pile, landfill, impoundment) is unstable, due to weak foundation soils or landslide potential, an imminent hazard may exist.

The potential for such problems to exist may be greater at locations described as high hazard and unstable terrains (see Section 2.2) than in other areas. When evaluating permit applications for facilities located in such terrains, the permit writer should always determine if an imminent hazard exists. Imminent hazards can exist in areas that are not considered to be high hazard and unstable terrains, however. In these circumstances, there may be a design or operation problem unrelated to a location limitation, such as inadequate dike compaction or resistance to erosion due to piping.

2) An aspect of the hydrogeologic character of the location, combined with a known leachate discharge, poses an imminent hazard to off-site ground-water or surface-water quality.

In this situation, there is no risk of massive physical failure or collapse of the facility. Rather, existing information indicates that there is or has been an ongoing or prior leachate release that may pose an imminent hazard to off-site ground or surface waters. This situation may occur at locations that fail the 'Ability to Monitor' and 'Vulnerable Hydrogeology' criteria (see Sections 2.3 and 2.5, respectively). In these cases, the Administrator may issue an order under Section 3008(h) requiring corrective action or such other response measure as he or she deems necessary to protect human health or the environment.

3.4.2 Considerations After Permit Issuance

The permit writer may determine that no imminent hazard exists prior to the time that the permit is issued, and that problems related to location can be satisfactorily addressed by permit conditions. If a permitted facility is in a setting that does not satisfy the location criteria listed in Section 2.0 of this manual, the permit writer should provide special tracking of permit compliance to ensure that an imminent hazard related to a location problem does not develop. This special tracking to ensure that the permit is in compliance should be planned through consultation between the permit writer and the Regional Office section responsible for facility inspections. State Agency personnel should be involved in the tracking to the extent that State Authorization or cooperative arrangements make it appropriate.

Under the new authority offered by Section 3004(u) of RCRA (Continued Release at Permitted Facilities), where a release of a hazardous waste or constituents is occurring from any solid waste management unit at a treatment, storage, or disposal facility, the Administrator may require a corrective action at a permitted facility to alleviate any hazard to public health and the environment. The use of this authority rather than the authority afforded by Section 7003, would be more appropriate in the case where a hazardous waste or constituent release is occurring at the facility.

4.0 CASE STUDIES FOR ANALYZING LOCATION CRITERIA AND EXISTING APPLICABLE REGULATIONS

Four case studies based on actual RCRA Part B permit applications have been summarized to demonstrate how a permit writer should evaluate whether a location meets the criteria for an acceptable location. Only those criteria having a regulatory or statutory basis are evaluated at this time. Methods for evaluating a vulnerable hydrogeology are reserved for the Phase II location guidance manual (available during late 1985). A more complete evaluation of each location highlighted in this section, as well as additional case studies in other locational settings, will be presented in Appendix E of the Phase II guidance manual.

Sixty six permit applications were reviewed during the fall of 1983 for information and data availability and completeness. Locations of facilities were sorted according to physiographic province and hydrogeologic setting. Two general classification systems were used in the sorting process. These systems are A.L. Charles Hunt's physiographic regions of the United States and Canada (1974) shown in Figure 4.0-1 and Ralph Heath's ground-water regions of the United States (1984) shown in Figure 4.0-2. The permit applications selected for case study represent a wide variety of locational settings appropriate for applying each of the criteria for an acceptable location. Table 4.0-1 lists the case study location, physiographic province, and ground-water region. Table 4.0-2 summarizes facility types, applicable location acceptance criteria evaluated, and permit action recommended for each of the four case studies discussed.

Each case study has a three-section format: (1) locational setting description, (2) hydrogeologic analysis, and (3) recommended permit action based on the first four location acceptance criteria. Information contained in the location setting description was taken directly from the Part B permit application. Editorial discretion was used to reduce text length and avoid redundance. The identity of the facility permit applicant and various consultants hired on behalf of the applicant have been omitted.

All facility owners or operators whose Part B permit applications were used in the case study evaluations were sent notices of deficiencies. Although certain sections of the application were complete, site characterization and related hydrogeologic information was not always complete. Additional information submitted to the Agency subsequent to the preparation of this manual could influence the location evaluation to some extent. For this reason, all case studies will eventually be supplemented with additional information that may have been received by permit writers in response to deficiency notices.

The location evaluation and comment presented in this section are currently under further study. Any position taken regarding case study facilities should not be interpreted as an official Agency decision for permit action.

The following subsections summarize the locational setting and evaluation for each case study.

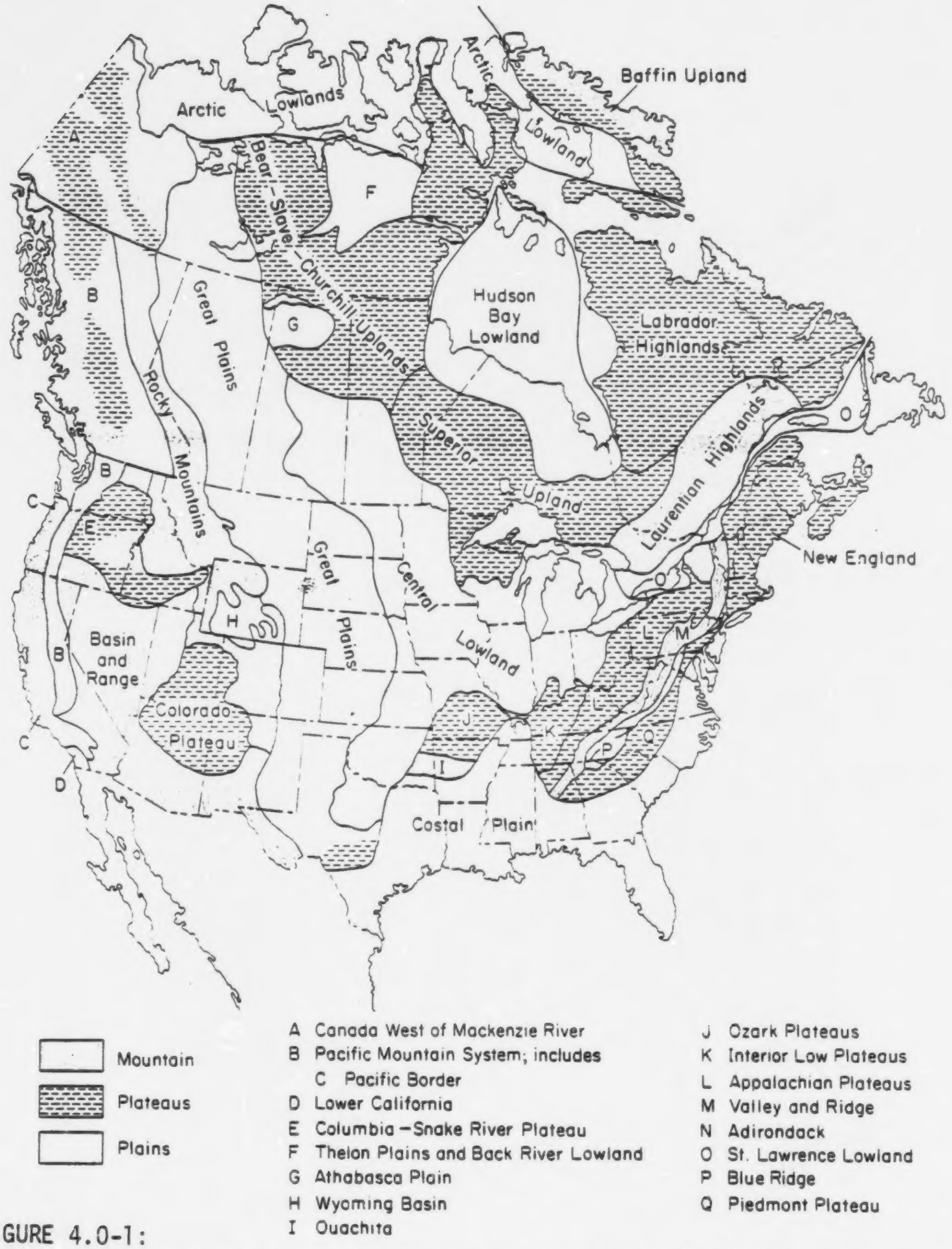

Baffin Upland
Arctic
Lowlands
Arctic
Lowland
A
Bear-Slave
F
Churchill Uplands
B
Great Plains
G
Hudson Bay Lowland
Labrador Highlands
Rocky Mountains
Superior Upland
O
Laurentian Highlands
B
C
E
New England
Great Plains
Central Lowland
H
N
L
M
B
Basin and Range
Colorado Plateau
C
D
J
K
P
Q
I
Costal Plain
Mountain
Plateaus
Plains
A Canada West of Mackenzie River
B Pacific Mountain System; includes
C Pacific Border
D Lower California
E Columbia–Snake River Plateau
F Thelon Plains and Back River Lowland
G Athabasca Plain
H Wyoming Basin
I Ouachita
J Ozark Plateaus
K Interior Low Plateaus
L Appalachian Plateaus
M Valley and Ridge
N Adirondack
O St. Lawrence Lowland
P Blue Ridge
Q Piedmont Plateau

FIGURE 4.0-1:

· Physicgraphic regions of the United States and Canada and their dominant landforms. About one-quarter of the land is mountains, one-quarter plateaus, and about half plains.

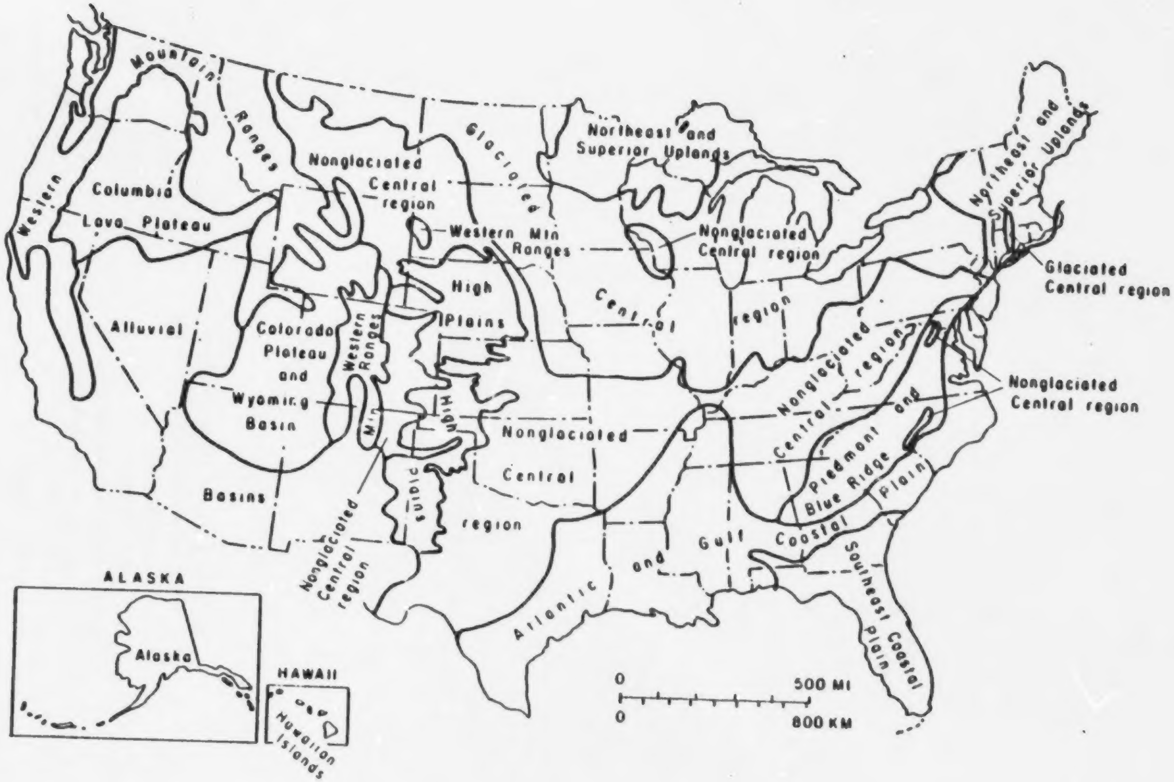

Western
Mountain
Ranges
Columbia
Lava Plateau
Alluvial
Basins
Nonglaciated
Central
region
Colorado
Plateau
and
Wyoming
Basin
Western
Ranges
Mtn
Western Mtn
Ranges
High
Plains
High
Plains
Glaciated
Central
region
Northeast and
Superior Uplands
Nonglaciated
Central region
Nonglaciated
Central
region
Nonglaciated
Central
region
Northeast and
Superior Uplands
Glaciated
Central region
Nonglaciated
Central region
Nonglaciated
Central region
Piedmont and
Blue Ridge
Coastal Plain
Atlantic and Gulf Coastal Plain
Southeast Coastal Plain
ALASKA
Alaska
HAWAII
Hawaiian
Islands
0
500 MI
0
800 KM

FIGURE 4.0-2: GROUND-WATER REGIONS OF THE UNITED STATES (AFTER HEATH, 1984)

Table 4.0-1: LIST OF CASE STUDY LOCATIONS AND LOCATIONAL SETTINGS

Case Study	Location	Physiographic Province (After Hunt, 1974)	Ground-Water Region After Heath, 1984)	Comment
A	Far Western United States	Pacific Border: Bay Mud	Alluvial Basin	Stratigraphy is 68 to 90 feet of compressible bay mud over clayey sediments.
B	Northeastern United States	Valley and Ridge	Non-glaciated Central Region	Stratigraphy shows strongly dipping, unfolded strata of sedimentary rocks. The site has been surface and subsurface mined. Complex hydrogeology.
C	Interior Western United States	Basin and Range	Alluvial Basin	Zero recharge zone location.
D	Southeastern United States	Coastal Plain: Mississippi Embayment	Coastal Plain	Stratigraphy is fill and clayey floodplain deposits over sand and gravel alluvium.

Table 4.0-2: MATRIX OF CASE STUDIES VERSUS RELEVANT LOCATION ACCEPTANCE CRITERIA

Case Study	Facility Type	Permit Action	Location Acceptance Criteria			
			Site Characterization	Protected Lands	High Hazard and Unstable Terrain	Ability to Monitor
A	Landfill	° Determine wetlands permit status ° Examine compliance with liner foundation standard ° Request information on flow paths	Insufficient	Wetland	Floodplain Seismic Weak Soil	Flow path not identified
B	Surface Impoundment	° Request flow path analysis and designation of uppermost aquifer	Insufficient; Uppermost aquifer not identified	No	Subsidence/ mine tunnels	Flow path not identified
C	Landfill	° Recommend for permit (conditionally)	Sufficient	No	No	Zero recharge zone
D	Surface Impoundment and Land Treatment	° Request flow path analysis and background monitoring justification	Insufficient	No	No	Flow path not identified; Background monitoring in doubt

4.1 CASE STUDY A

Location:	Far Western United States
Type of Facility:	Landfills and surface impoundments
Physiographic Setting:	Bay mud

The facility totals approximately 535 acres, and is divided into a north and south parcel. The north parcel contains an existing 125-acre sanitary landfill used for the disposal of hazardous waste and a 20-acre surface impoundment previously used for the disposal of hazardous waste.

The owner has proposed to extend the north parcel landfill onto virgin marsh bay muds adjacent to the current landfill. Nearby land uses are primarily of industrial character (petroleum chemical storage tanks) with limited residential use. Test borings in this area indicate that the entire north parcel is underlain by weak, compressible, peaty and silty marsh deposits of low permeability known as bay mud. The bay mud varies in thickness from 4 to 62 feet and is underlain by relatively incompressible, moderately strong silts and clays of low permeability. In turn, these sediments are underlain by moderately hard to fractured sandstone and shale formations (see the site plan and geologic cross-sections in Figures 4.1-1 through 4.1-4).

Laboratory tests performed on the bay mud indicate that vertical permeabilities range between 1.8×10^{-6} and 3.0×10^{-7} cm/sec. Slug testing showed the horizontal permeability to range between 5.2×10^{-4} and 1.9×10^{-5} cm/sec. Enforcement actions were taken to require the repair of leaks in surface impoundment dikes at the facility.

4.1.1. Summary of Locational Evaluation

- The facility is within the 100-year flood/tide zone of a local creek. The facility is also to be sited in an area described as "marsh" and, therefore, may be in a wetland as defined in Section 404 of the Clean Water Act.
- The facility is suspected to overlie an active fault, but no direct evidence was presented in the application to conclusively support this assertion.
- The facility will be subject to ground motion during seismic activity and may be impacted by numerous active faults in the proximity of the site. As a result of this ground motion the facility is expected to experience permanent displacement of landfill slopes and further displacements due to creeping of the marsh soils. These displacements may threaten the integrity of the landfill and caps. Continuous maintenance of the engineered containment structure will likely be required.
- The facility is expected to settle into the bay mud up to one quarter of its design thickness within thirty years of facility closure. The permit application does not state if further settle will occur after thirty years but additional settlement seems likely. Settlement of this magnitude will threaten the integrity of the landfill cap and liner and require continuous maintenance.
- As a result of an expected rise in sea level, the elevation of the 100-year flood may also rise above protecting dikes and expose the facility to wash out within the predictable future. This rise may occur prior to closure.
- The uppermost aquifer is the bay mud deposit with bay mud water table elevations at the land surface. The bay mud is relatively impermeable vertically (1×10^{-6} cm/sec) but is one to two orders of magnitude more permeable horizontally.
- Information concerning ground-water flow gradients was not supplied.
- The principle ground-water flow pathways for pollutant migration are horizontal flow in the bay mud with discharge to a nearby creek. Time of travel for 100 feet horizontally in bay muds was calculated to be 15.2 years. Waste escaping the

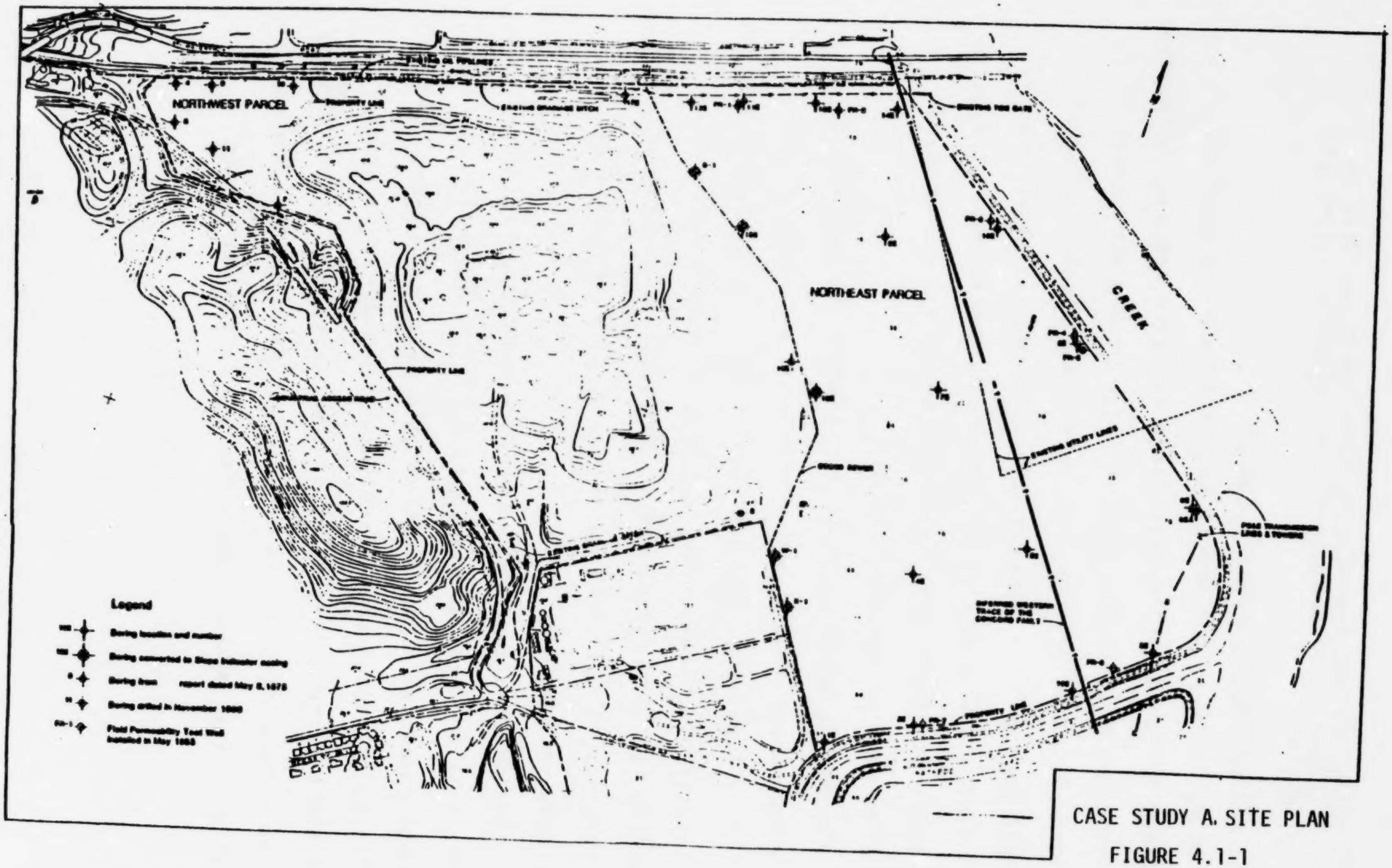
facility and discharging into the creek will be diluted to an unknown extent, possibly below safe levels.

4.1.2 Discussion of Location Issues

At facility A, the permit writer determined that the location fails all of the location acceptance criteria and is, therefore, an unacceptable location. The evidence of bay mud instability under the landfill load and during seismic events indicates an unstable geologic environment that will require perpetual monitoring and maintenance of engineered containment structures. The threat of instability is compounded by the prospect of sea level rise in the near future.

The permit applicant does not address key elements of a characterization such as the presence of wetlands, groundwater flow gradients, and sea level rise. The uppermost aquifer was incorrectly identified. Based on available information regarding the site hydrology, it appears that constituents escaping the facility may move rapidly offsite, possible to a creek near the site.

A mitigating factor that must be considered at this location is the attenuative capacity of the bay mud. The bay mud possesses a high content of organic carbon and clay minerals. Although these materials are known to attenuate selected hazardous constituents, the exact level of attenuation cannot be predicted and is constituent specific. No documentation of attenuative capacity was presented in the permit application.


NORTHWEST PARCEL
NORTHEAST PARCEL
CREEK
PROPERTY LINE
EXISTING DRAINAGE DITCH
EXISTING UTILITY LINES
INFERRED WESTERN TRACE OF THE CONCORD FAULT
Legend
Boring location and number
Boring converted to Slope Indicator casing
Field Permeability Test Well

CASE STUDY A. SITE PLAN

FIGURE 4.1-1

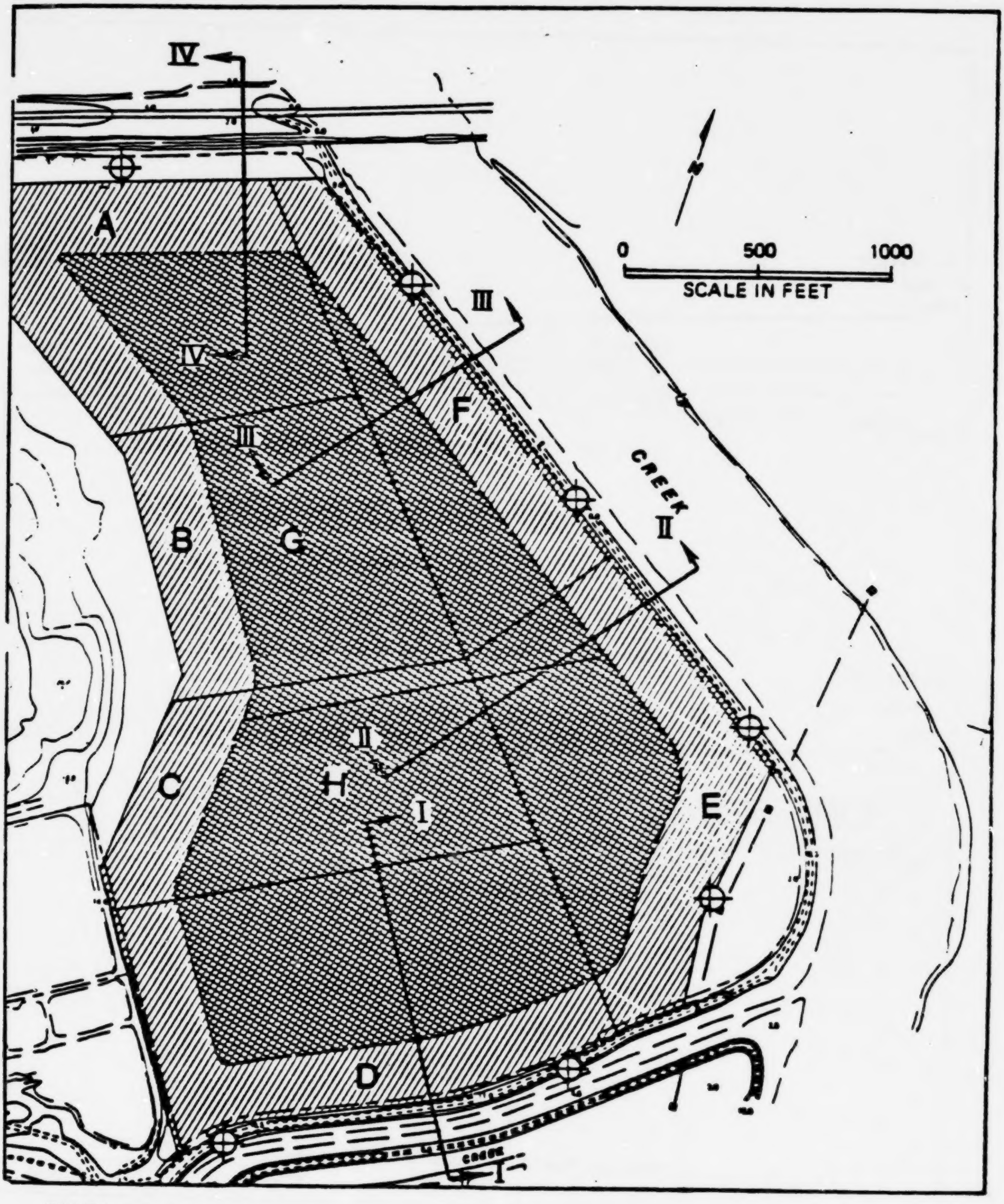
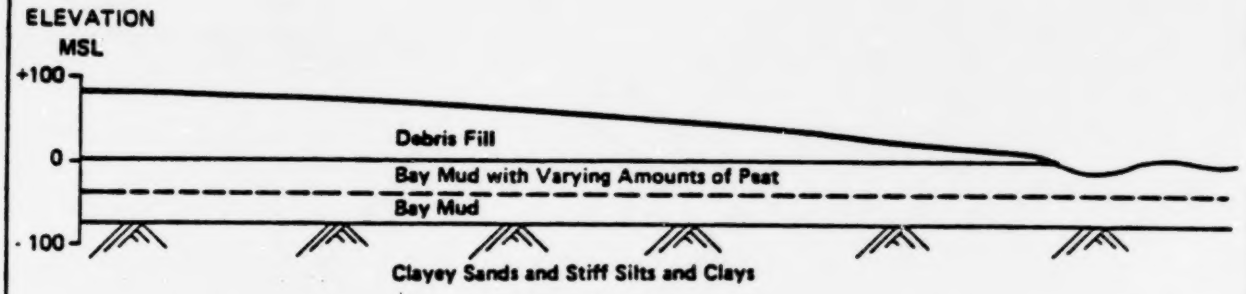
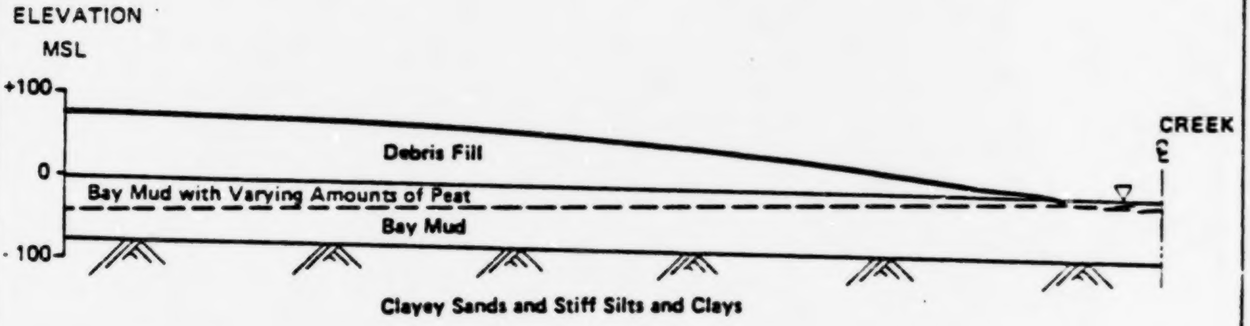

IV
IV
III
III
II
II
I
I
A
B
C
D
E
F
G
H
CREEK
N
0
500
1000
SCALE IN FEET

FIGURE 4.1-2
CASE STUDY A: LOCATION OF CROSS SECTIONS


ELEVATION
MSL
+100
0
- 100
Debris Fill
Bay Mud with Varying Amounts of Peat
Bay Mud
Clayey Sands and Stiff Silts and Clays

SECTION I – I


ELEVATION
MSL
+100
0
- 100
CREEK
℄
Debris Fill
Bay Mud with Varying Amounts of Peat
Bay Mud
Clayey Sands and Stiff Silts and Clays

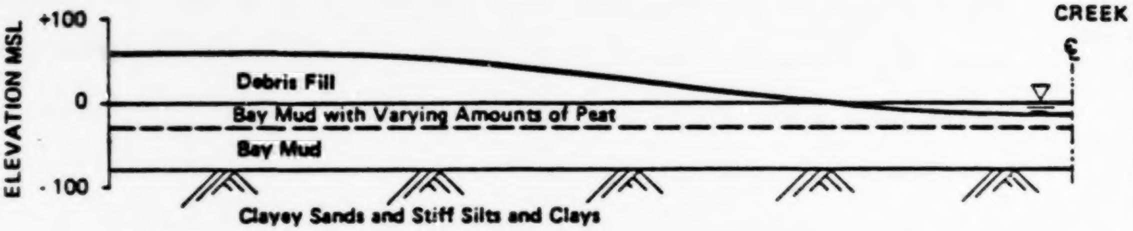
SECTION II – II

0 100 feet

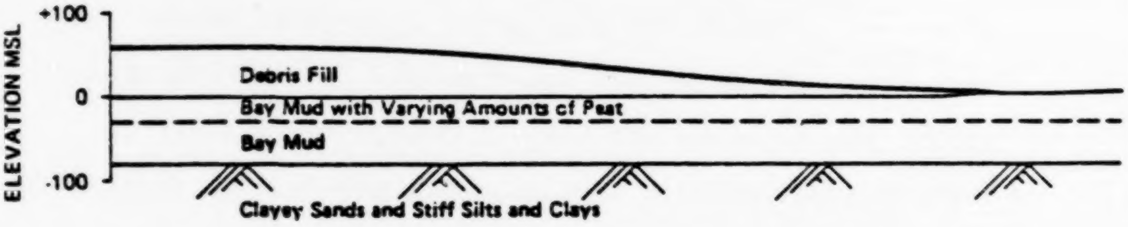
SCALE

Note: See Plate C1 for Location of Cross Sections

FIGURE 4.1-3
CASE STUDY A: SECTIONS I-I' AND II-II'


+100
0
-100
ELEVATION MSL
CREEK
℄
Debris Fill
Bay Mud with Varying Amounts of Peat
Bay Mud
Clayey Sands and Stiff Silts and Clays

SECTION III – III'


+100
0
-100
ELEVATION MSL
Debris Fill
Bay Mud with Varying Amounts of Peat
Bay Mud
Clayey Sands and Stiff Silts and Clays

SECTION IV – IV'

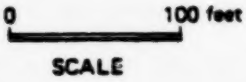

0
100 feet
SCALE

FIGURE 4.1-4
CASE STUDY A: SECTIONS III-III' AND IV-IV'

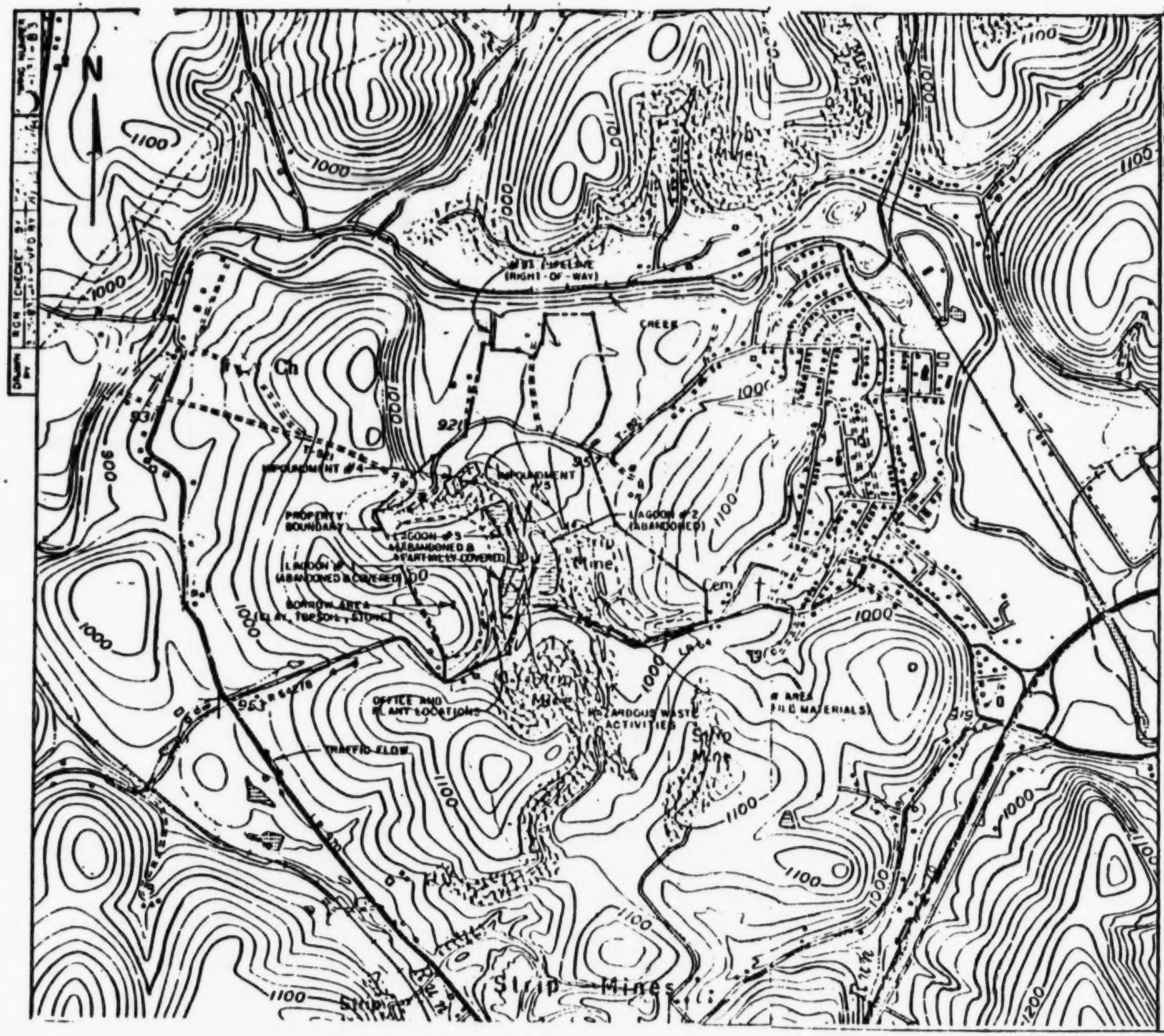
4.2 CASE STUDY B

Location:	Northeastern United States
Facility Type:	Surface impoundments, waste pile
Physiographic Province:	Appalachian Mountains

Located on a 200 acre site, the facility consists of a waste treatment operation, three liquid waste holding tanks, a prepared surface for solid waste holding, a surface impoundment for holding recycled water (SI-4), and a surface impoundment for disposal (SI-5). In addition, the site also contains three abandoned surface impoundments which were previously utilized for ultimate disposal.

The local geology is complex and cannot be easily summarized. Several maps and geologic cross-sections were prepared by the applicant and are included in Figures 4.2-1 through 4.2-5. Dipping, nonfolded strata of sedimentary rock are covered by a layer of alluvium and fill. Coal seams have been surface mined and subsurface mined on the site.

It is difficult if not impossible to determine all potential ground-water flow paths that exist beneath this facility. One flow path not discussed by the applicant is within the alluvium and fill, flowing toward a minor tributary adjacent to Impoundment 4 (SI-4). An examination of topographic surface contours shows that Impoundment 5 (SI-5) was built within a branch of the unnamed tributary. Gradients beneath the surface impoundments will be large in the event of liner failure due to 35 feet or more of static hydraulic head in the impoundments. More hydrogeologic information is required to completely assess the potential for flow in the alluvium and surface soils.


N
1100
1000
900
1000
1100
1200
Ch
921
931
953
95
T-921
IMPOUNDMENT #4
IMPOUNDMENT #5
PROPERTY BOUNDARY
LAGOON #3 (ABANDONED & PARTIALLY COVERED)
LAGOON #1 (ABANDONED & COVERED)
BORROW AREA (CLAY, TOPSOIL, STONE)
LAGOON #2 (ABANDONED)
Mine
Cem
OFFICE AND PLANT LOCATIONS
HAZARDOUS WASTE ACTIVITIES
AREA (FILL MATERIALS)
TRAFFIC FLOW
PIPELINE (RIGHT-OF-WAY)
CREEK
Strip Mines
Strip Mine

REFERENCE:

U.S.G.S. 7.5 MINUTE SERIES (TOPOGRAPHIC)
QUADRANGLE
SCALE: 1" = 2000'
PHOTOREVISED 1969

FIGURE 4.2-1
CASE STUDY B TOPO MAP

SCALE
0 1000 2000 FEET

FIGURE 4.2-2
CASE STUDY B:
BORINGS AND WELL MAP

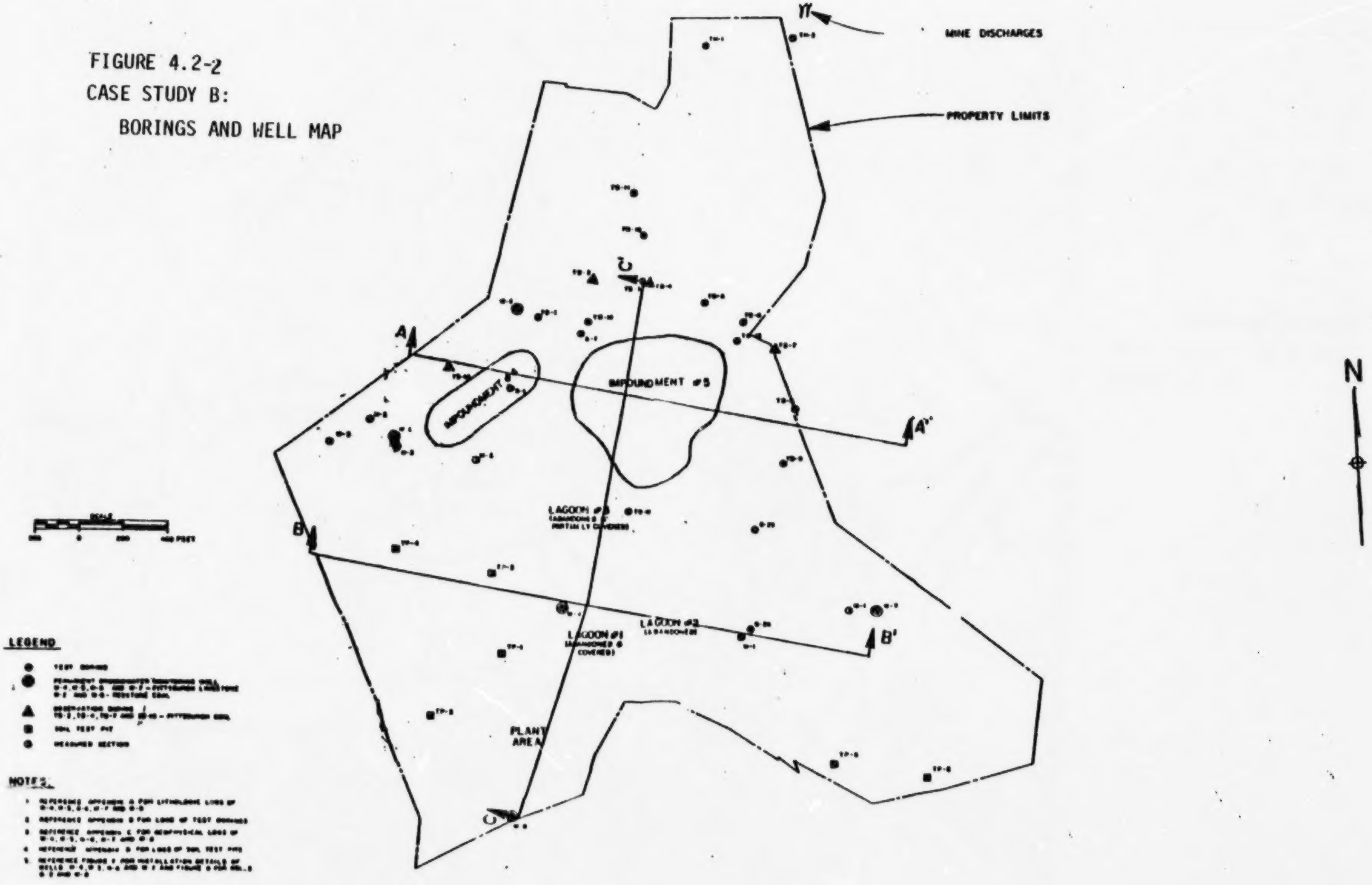
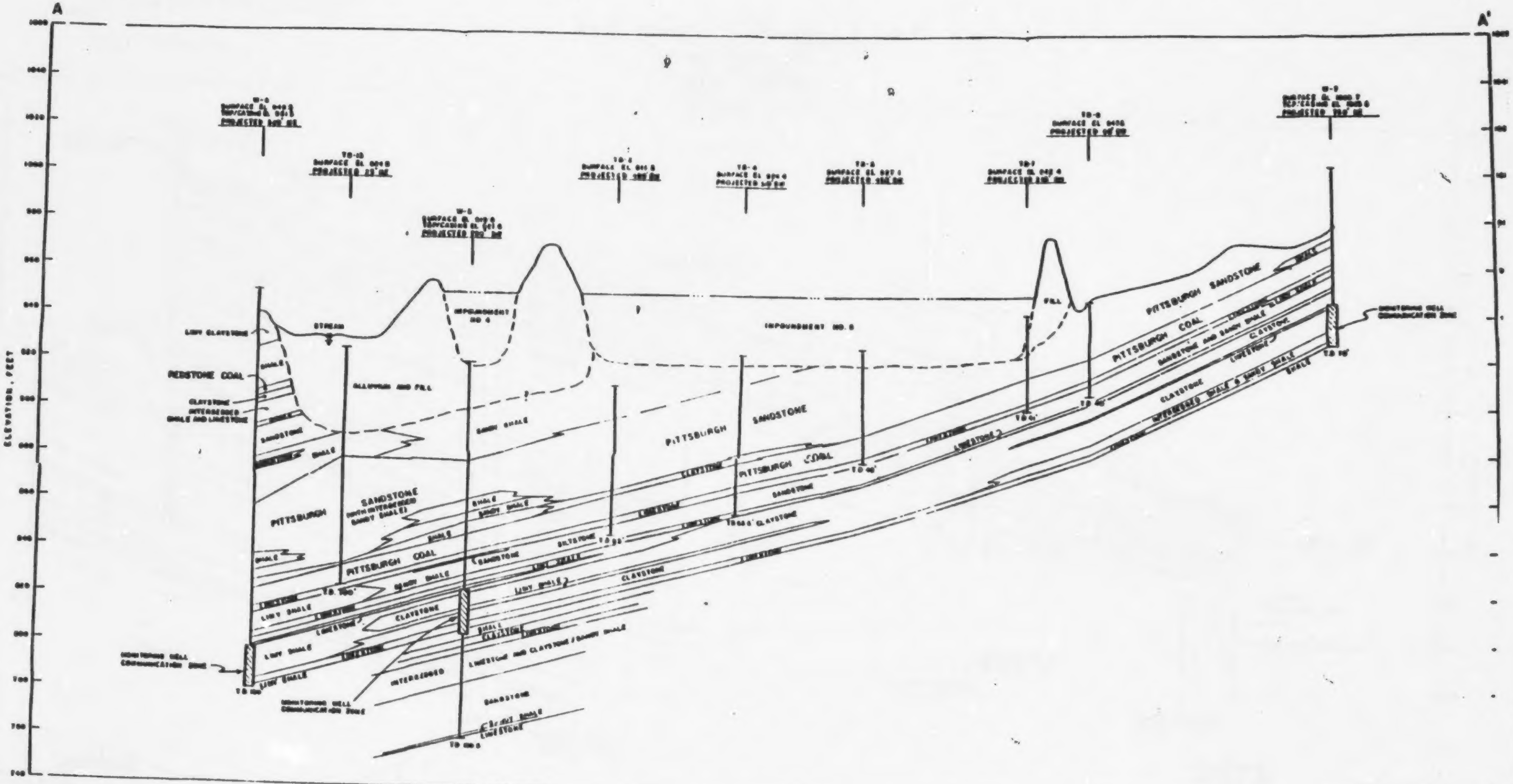

MINE DISCHARGES
PROPERTY LIMITS
IMPOUNDMENT #5
IMPOUNDMENT
LAGOON #3 (ABANDONED & PARTIALLY COVERED)
LAGOON #1 (ABANDONED & COVERED)
LAGOON #2 (ABANDONED)
PLANT AREA
A
A'
B
B'
C
C'
N
SCALE
400 FEET
LEGEND
TEST BORING
SOIL TEST PIT
MEASURED SECTION
NOTES:

FIGURE 4.2-3


A
A'
ELEVATION, FEET
W-3
SURFACE EL
PROJECTED
TD-10
SURFACE EL
PROJECTED
W-5
SURFACE EL
TOP/CASING EL
PROJECTED
TD-2
TD-4
TD-5
TD-7
TD-8
W-9
SURFACE EL
TOP/CASING EL
PROJECTED
LIGHT CLAYSTONE
REDSTONE COAL
CLAYSTONE
INTERBEDDED SHALE AND LIMESTONE
SHALE
SANDSTONE
LIMESTONE
STREAM
ALLUVIUM AND FILL
IMPOUNDMENT NO 4
SANDY SHALE
PITTSBURGH SANDSTONE (WITH INTERBEDDED SANDY SHALE)
PITTSBURGH COAL
SILTSTONE
LIMY SHALE
CLAYSTONE
LIMESTONE AND CLAYSTONE / SANDY SHALE
INTERBEDDED
MONITORING WELL COMMUNICATION ZONE
SANDY SHALE
LIMESTONE
IMPOUNDMENT NO. 5
PITTSBURGH SANDSTONE
FILL
SANDSTONE AND SANDY SHALE
INTERBEDDED SHALE & SANDY SHALE
LIMESTONE 2
T.D.
HORIZONTAL SCALE
100
0
100
200 FEET
VERTICAL SCALE
20
0
20
40 FEET

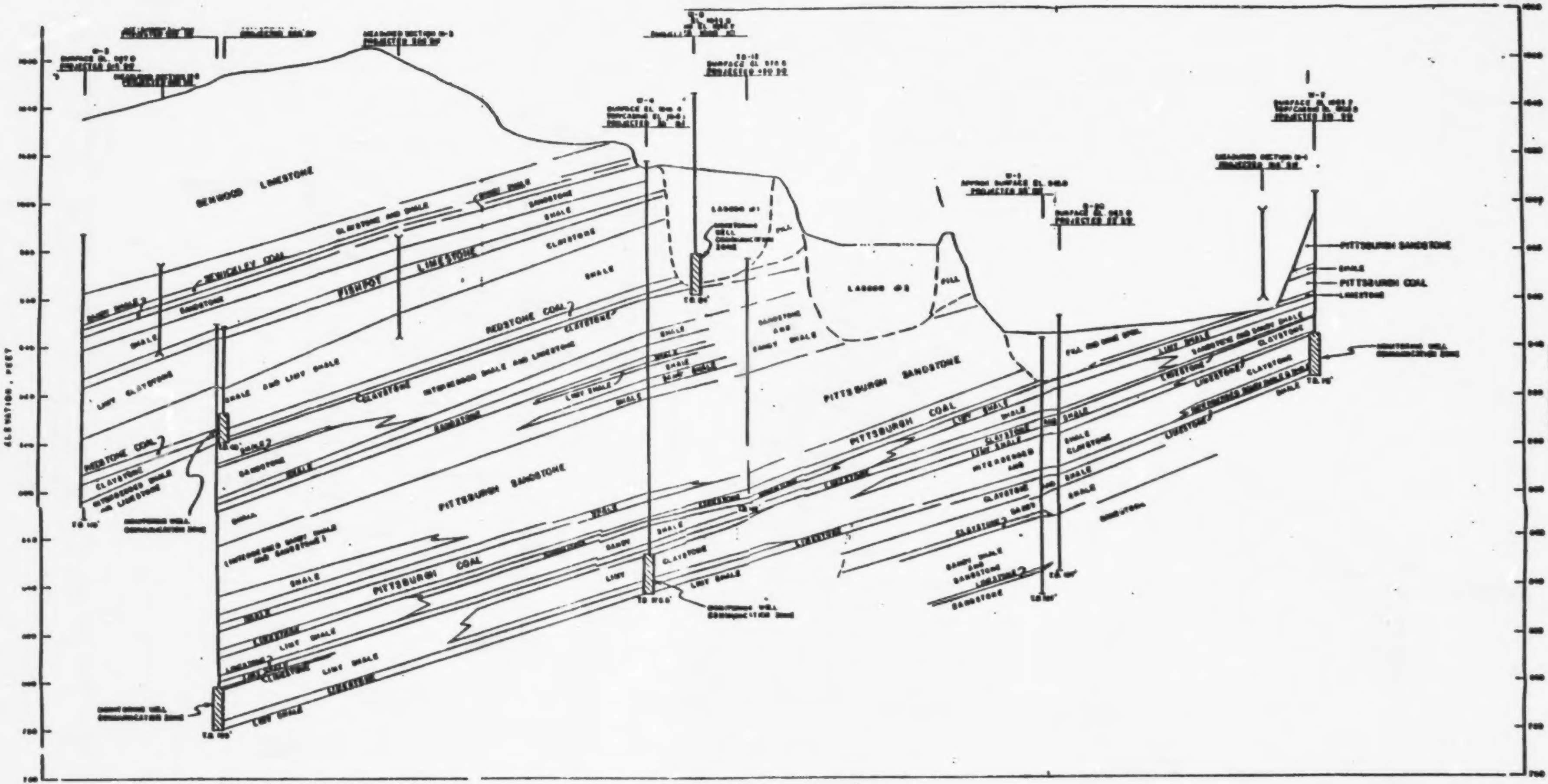
CASE STUDY B

SECTION A-A'
(LOOKING NORTHEAST)
(5 X VERTICAL EXAGGERATION)

NOTES

1 REFERENCE FIGURE 2 FOR PLAN LOCATION OF CROSS SECTION
2 REFERENCE FIGURE [illegible]

FIGURE 4.2-4



ELEVATION, FEET
BENWOOD LIMESTONE
SEWICKLEY COAL
FISHPOT LIMESTONE
REDSTONE COAL
CLAYSTONE AND SHALE
INTERBEDDED SHALE AND LIMESTONE
PITTSBURGH SANDSTONE
PITTSBURGH COAL
LAGOON #1
LAGOON #2
FILL
SHALE
CLAYSTONE
LIMESTONE
SANDSTONE
LIMY SHALE
SANDY SHALE
LIMESTONE
MONITORING WELL COMMUNICATION ZONE

SECTION B-B'
(LOOKING NORTHEAST)
(8-X VERTICAL EXAGGERATION)

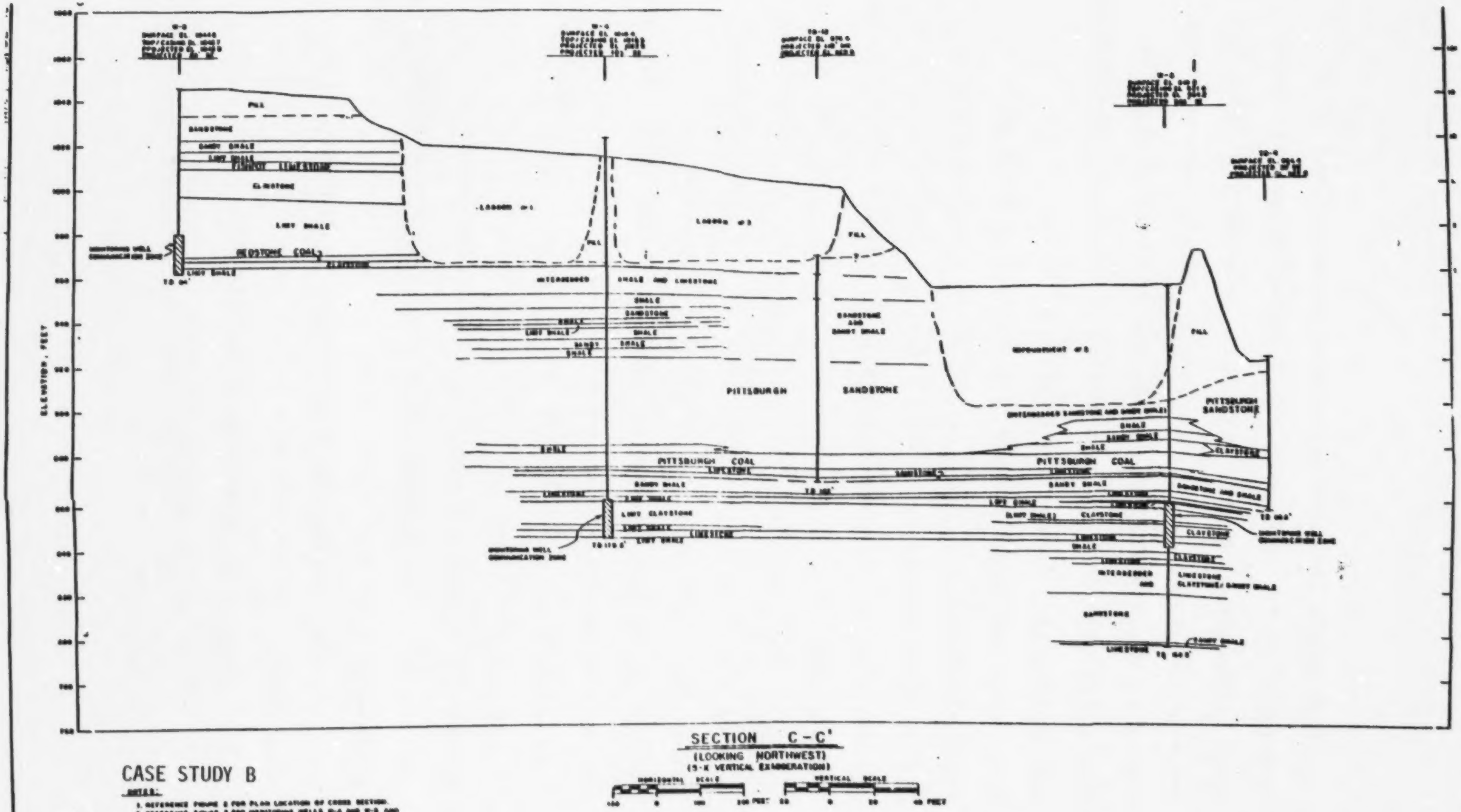
CASE STUDY B

NOTES:

1. REFERENCE FIGURE [illegible] FOR PLAN LOCATION OF CROSS SECTION.
2. REFERENCE FIGURE [illegible] FOR MONITORING WELLS [illegible] AND FIGURE [illegible] FOR [illegible] DETAILS.
3. REFERENCE APPENDICES A AND B FOR LITHOLOGIC LOGS OF BORINGS SHOWN.
4. ALL BORINGS AND MEASURED SECTIONS ARE PROJECTED PARALLEL TO THE LOCAL LINE OF STRIKE.
5. LITHOLOGIC BOUNDARIES INFERRED BETWEEN BORINGS.

THIS CROSS SECTION DEPICTS GEOLOGIC CONDITIONS AT SPECIFIC LOCATIONS SHOWN BASED UPON OBSERVATIONS OF MATERIALS ENCOUNTERED AND DATA PROVIDED. GEOLOGIC STRATA AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE SITES.

FIGURE 4.2-5


ELEVATION, FEET
1080
1060
1040
1020
1000
980
960
940
920
900
880
860
840
820
800
780
760
W-8
W-4
TB-10
W-5
TB-9
FILL
SANDSTONE
SANDY SHALE
SILTY SHALE
LIMESTONE
CLAYSTONE
SILTY SHALE
REDSTONE COAL
LAGOON #1
LAGOON #2
IMPOUNDMENT #3
MONITORING WELL COMMUNICATION ZONE
INTERBEDDED SHALE AND LIMESTONE
SANDSTONE AND SANDY SHALE
PITTSBURGH SANDSTONE
PITTSBURGH COAL
INTERBEDDED SANDSTONE AND SANDY SHALE
HORIZONTAL SCALE
VERTICAL SCALE
100 FEET
40 FEET

SECTION C-C'
(LOOKING NORTHWEST)
(5-X VERTICAL EXAGGERATION)

CASE STUDY B

NOTES:

1. REFERENCE FIGURE [illegible] FOR PLAN LOCATION OF CROSS SECTION.
2. REFERENCE FIGURE [illegible] FOR MONITORING WELLS W-4 AND W-5 AND FIGURE [illegible] FOR W-8 INSTALLATION DETAILS.
3. REFERENCE APPENDICES A AND B FOR LITHOLOGIC LOGS OF BORINGS SHOWN.
4. ALL BORINGS ARE PROJECTED [illegible] PERPENDICULAR TO THE LOCAL LINE OF STRIKE.
5. LITHOLOGIC BOUNDARIES INFERRED BETWEEN BORINGS.

THIS CROSS SECTION DEPICTS GEOLOGIC CONDITIONS AT
SPECIFIC LOCATIONS SHOWN BASED UPON OBSERVATIONS
OF MATERIALS ENCOUNTERED AND DATA PROVIDED.
GEOLOGIC STRATA AT OTHER LOCATIONS
MAY [illegible] FROM CONDITIONS OCCURRING AT THESE SITES.

Flow paths into the Pittsburgh Sandstone and lower lithologic units, including the Pittsburgh Coal and Pittsburgh Limestone, are very difficult to predict. Normally, recharge of ground water into dipping layers such as these occurs in the limited area where the strata outcrops; in this case, east and upgradient from the surface impoundments and waste pile. However, vertical fractures in the Pittsburgh Sandstone present a cross-strata flow path. These fractures are likely a result of subsidence due to mining of the Pittsburgh Coal. Should leachate leaking from the units reach the coal and limestone strata, contaminants would migrate with the regional flow toward the west and downdip. This flow path is complicated by the numerous mine tunnels within the Pittsburgh coal seam. Several borings (TB-6, TB-7, and TB-8) indicate mine tunnel voids 20 feet to 92 feet from the surface directly under the impoundments. In addition, the state has documented that two abandoned mine tunnels are located from 40 to 90 feet below the base of the surface impoundment dike. Predicting flow in these mine tunnels is impossible based on data in the permit application. It appears likely that leachate reaching the Pittsburgh Coal seam would reach a mine tunnel. It is also possible that during the construction of Impoundment 5, flow paths to a shallow mine tunnel were created.

4.2.1 Summary of Locational Evaluation

- The permit application does not contain information which would indicate that the facility is located on protected lands.

- Surface Impoundment 5 was built in a former stream channel receiving surface water from a watershed of approximately 425 acres.

- The potential for subsidence due to mine tunnel collapse was not addressed by the applicant. The prevalence of mine tunnel voids may result in subsidence that may eventually cause liner foundation failure and cover subsidence. The facility is located in a high hazard and unstable terrain.

- Flow paths beneath the facility are difficult to predict. The hydrogeology is complex due to dipping strata, alluvium, and both surface and subsurface mining. Information on water tables in the alluvium and the hydraulic properties of the alluvium are not provided in the application. Further information regarding flow paths and additional technical review should be conducted regarding the hydrogeology of the site.

- Landowners with wells located adjacent to the facility pump drinking water from seeps that may be recharged with ground water beneath the site of the facility.

4.2.2 Discussion of Location Issues

Given the lack of essential information and the hydrogeologic complexity of the location, this site was classified as unacceptable for the land disposal of hazardous waste since it would not meet the criteria for site characterization and ability to monitor ground water. In the event of facility failure, leaking waste would migrate along unpredictable flow paths that the owner/operator could not monitor for ground-water quality data. Corrective action would also be inhibited.

4.3 CASE STUDY C

Location:	Interior Western United States
Type of Facility:	Landfill
Physiographic Province:	Basin and Range

The facility is located in a desert environment and covers approximately 80 acres. Waste disposed in the landfill includes inorganic acids, oxidizers and bases, pesticides, cyanides, metals and metallic salts, and solvents. Except for 'de minimus' quantities of liquids contained in lab packs, no liquids are presently being disposed in the landfill.

Bedrock units at the site are identified as metamorphic rock covered by unconsolidated or weakly-cemented Quaternary alluvial materials. These alluvial or valley-fill deposits have been shown by drilling records to be at least 570 feet thick beneath the site. The valley-fill deposits are silts, sands, gravels, and cobbles of local origin, composed primarily of volcanic rock, which have been transported to the site by a combination of gravity and water transport. No distinct boundary exists between the bajada or alluvial fan deposits and desert flat deposits. The bajada deposits in this area are primarily coarse grained, becoming finer with increased distance from the mountain front. Desert flat materials are a combination of fine-to coarse-grained materials laid down at the lower ends of alluvial fans and in alluvial deposits of valley streams, and generally fine-grained materials deposited in basinal lakes. As a result of variable-source areas and depositional mechanisms, bajada-desert flat deposits are typically anisotropic and are unsaturated to depths of approximately 300 feet.

Individual beds of materials at the site are not continuous due to the depositional environment and finer grained horizons cannot be relied upon to act as barriers to migration (see the accompanying site plan and geologic cross-sections in Figures 4.3-1 through 4.3-6).

The applicant claims that leakage from the landfill will not migrate to the uppermost aquifer because existing ground water lies beneath a minimal recharge zone. The two principle pathways for leachate migration in an arid, low recharge environment are vertically upward and vertically downward. Some horizontal movement may occur due to depositional mechanisms that create hydraulically anisotropic conditions. A consultant report indicates that lateral migration has occurred due to pre-RCRA waste activities. Under unsaturated conditions, soil moisture moves from wet regions to dry regions. In the low recharge environment, moisture cycles in a vertical plane. During storm events, moisture infiltrates into the dry subsoil and is again drawn to the soil surface when evapotranspiration increases following a storm. Moisture movement in the unsaturated zone is also strongly controlled by the grain size of sediments, in which capillarity will cause preferential movement in finer grained materials.

Moisture must accumulate during a moisture cycle for ground-water recharge to occur. It was calculated that percolation at the site would occur during only three months over the course of the 60-year period of weather record.

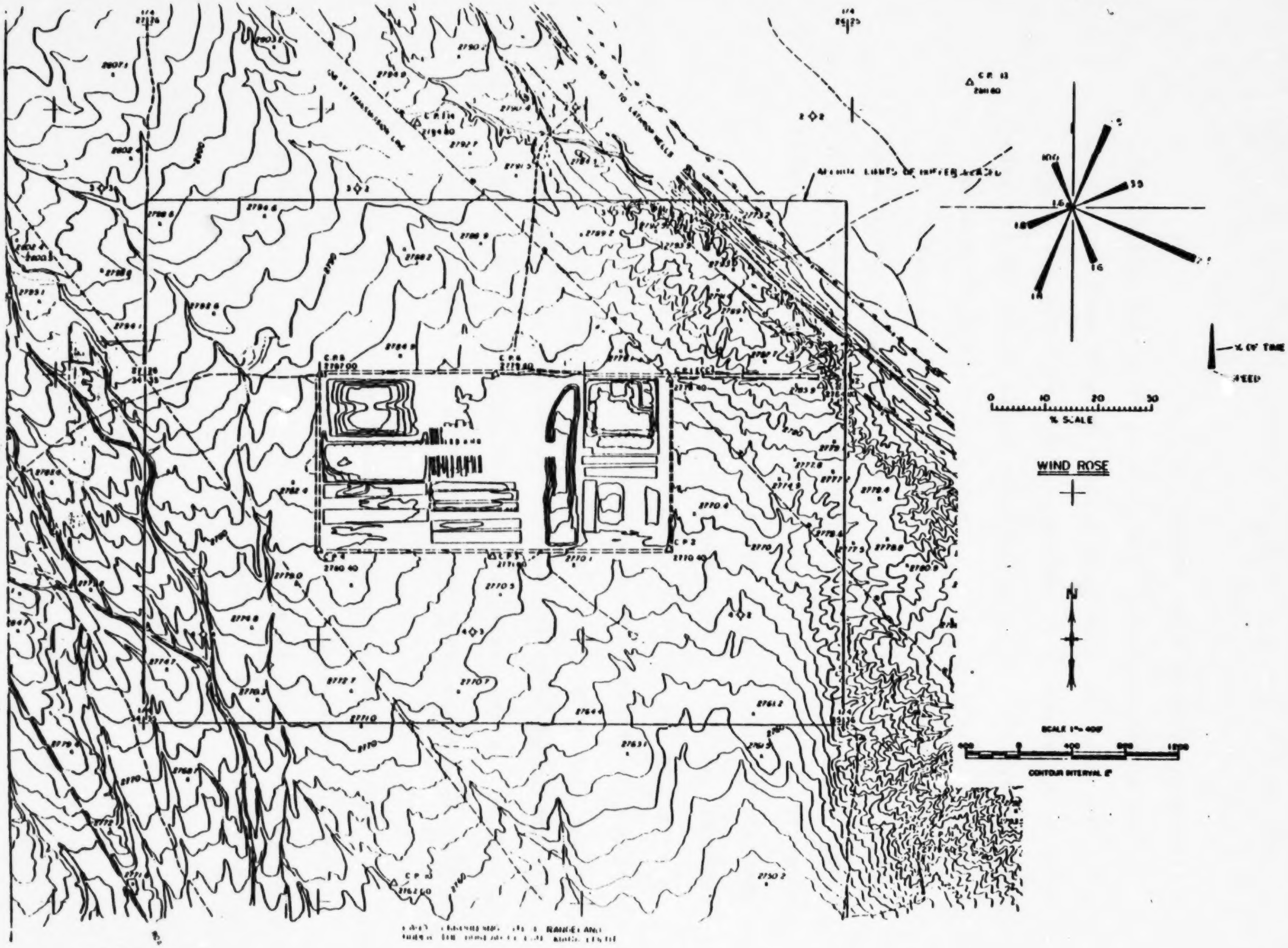

WIND ROSE
% SCALE
0
10
20
30
% OF TIME
SPEED
16
33
16
18
14
N
SCALE 1" = 400'
400
0
400
800
1200
CONTOUR INTERVAL 2'

FIGURE 4.3-1

CASE STUDY C TOPOGRAPHIC MAP

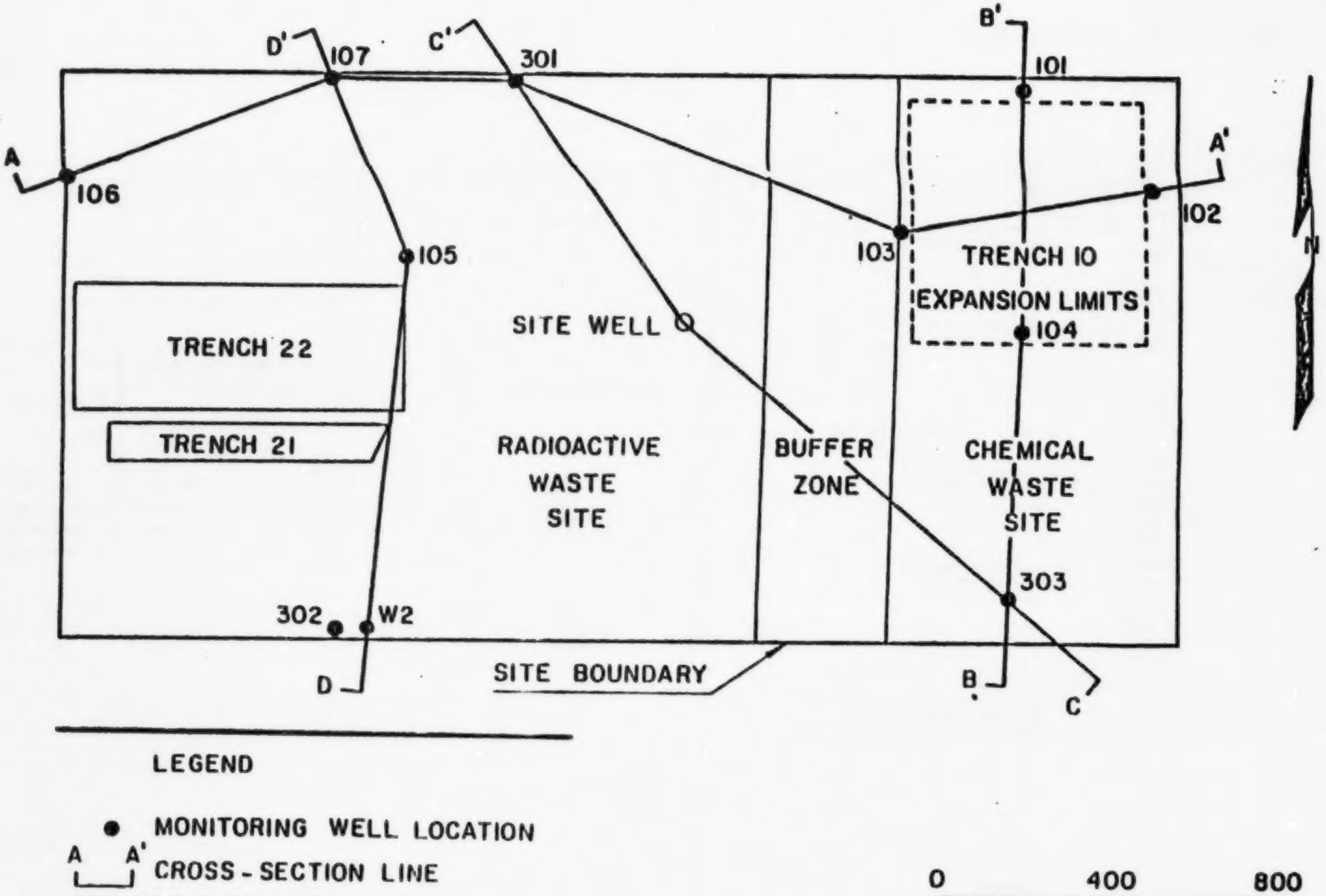

D'
107
C'
301
B'
101
A'
A
106
102
105
103
TRENCH 10
EXPANSION LIMITS
104
N
TRENCH 22
SITE WELL
TRENCH 21
RADIOACTIVE
WASTE
SITE
BUFFER
ZONE
CHEMICAL
WASTE
SITE
303
302
W2
D
SITE BOUNDARY
B
C
LEGEND
● MONITORING WELL LOCATION
A A' CROSS - SECTION LINE
0
400
800
FEET

FIGURE 4.3-2
CASE STUDY C: LOCATION OF CROSS SECTIONS

FIGURE 4.3-3

CASE STUDY C CROSS SECTION A-A'

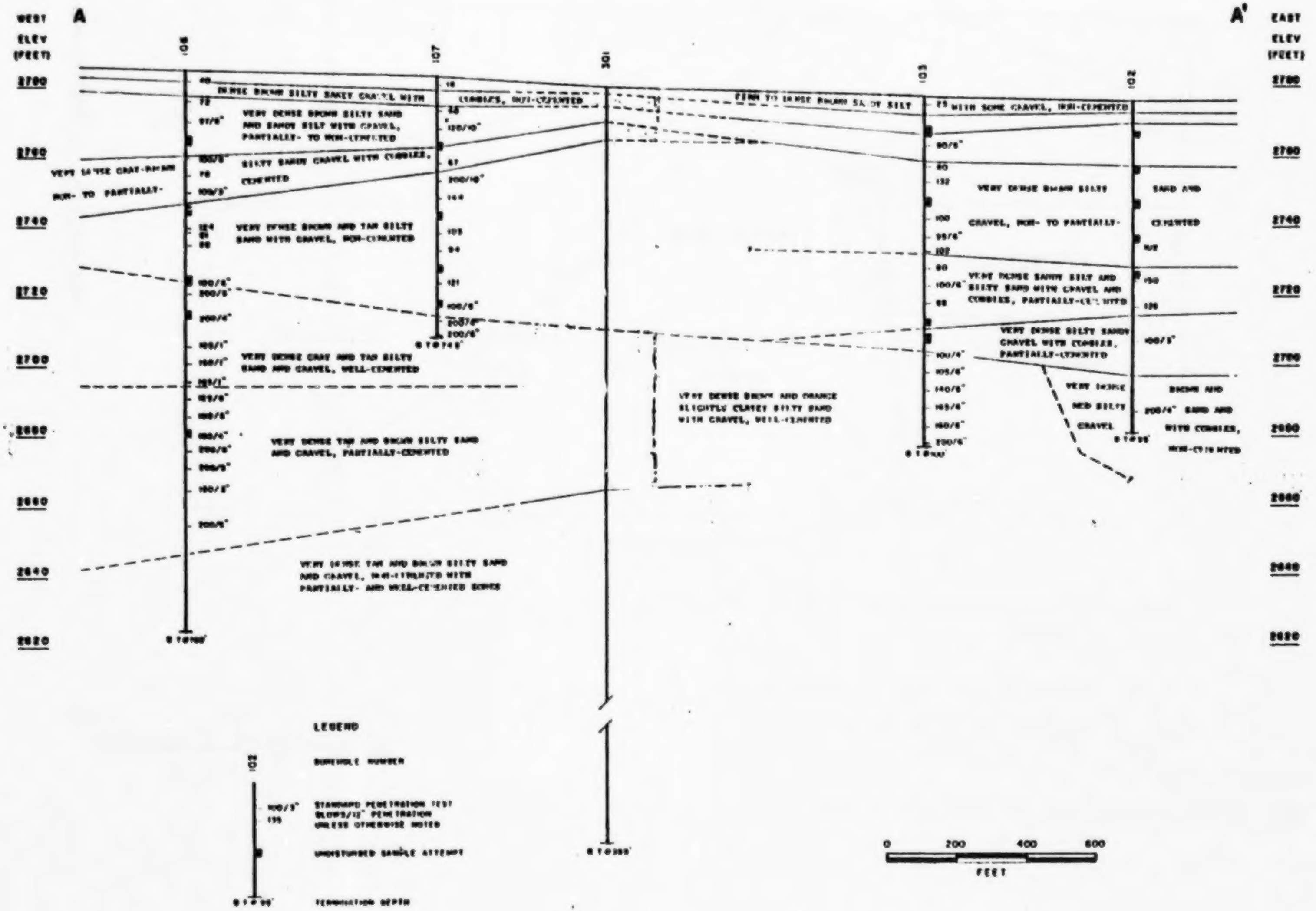

WEST
ELEV
(FEET)
A
A'
EAST
ELEV
(FEET)
2780
2760
2740
2720
2700
2680
2660
2640
2620
106
107
301
103
102
DENSE BROWN SILTY SANDY GRAVEL WITH COBBLES, NON-CEMENTED
VERY DENSE BROWN SILTY SAND AND SANDY SILT WITH GRAVEL, PARTIALLY- TO NON-CEMENTED
VERY DENSE GRAY-BROWN SILTY SANDY GRAVEL WITH COBBLES, NON- TO PARTIALLY-CEMENTED
VERY DENSE BROWN AND TAN SILTY SAND WITH GRAVEL, NON-CEMENTED
VERY DENSE GRAY AND TAN SILTY SAND AND GRAVEL, WELL-CEMENTED
VERY DENSE TAN AND BROWN SILTY SAND AND GRAVEL, PARTIALLY-CEMENTED
VERY DENSE TAN AND BROWN SILTY SAND AND GRAVEL, NON-CEMENTED WITH PARTIALLY- AND WELL-CEMENTED ZONES
FIRM TO DENSE BROWN SANDY SILT WITH SOME GRAVEL, NON-CEMENTED
VERY DENSE BROWN SILTY SAND AND GRAVEL, NON- TO PARTIALLY-CEMENTED
VERY DENSE SANDY SILT AND SILTY SAND WITH GRAVEL AND COBBLES, PARTIALLY-CEMENTED
VERY DENSE SILTY SANDY GRAVEL WITH COBBLES, PARTIALLY-CEMENTED
VERY DENSE BROWN AND RED SILTY SAND AND GRAVEL WITH COBBLES, NON-CEMENTED
VERY DENSE BROWN AND ORANGE SLIGHTLY CLAYEY SILTY SAND WITH GRAVEL, WELL-CEMENTED
LEGEND
BOREHOLE NUMBER
STANDARD PENETRATION TEST BLOWS/12" PENETRATION UNLESS OTHERWISE NOTED
UNDISTURBED SAMPLE ATTEMPT
TERMINATION DEPTH
0
200
400
600
FEET

FIGURE 4.3-4
CASE STUDY C CROSS SECTION B-B'

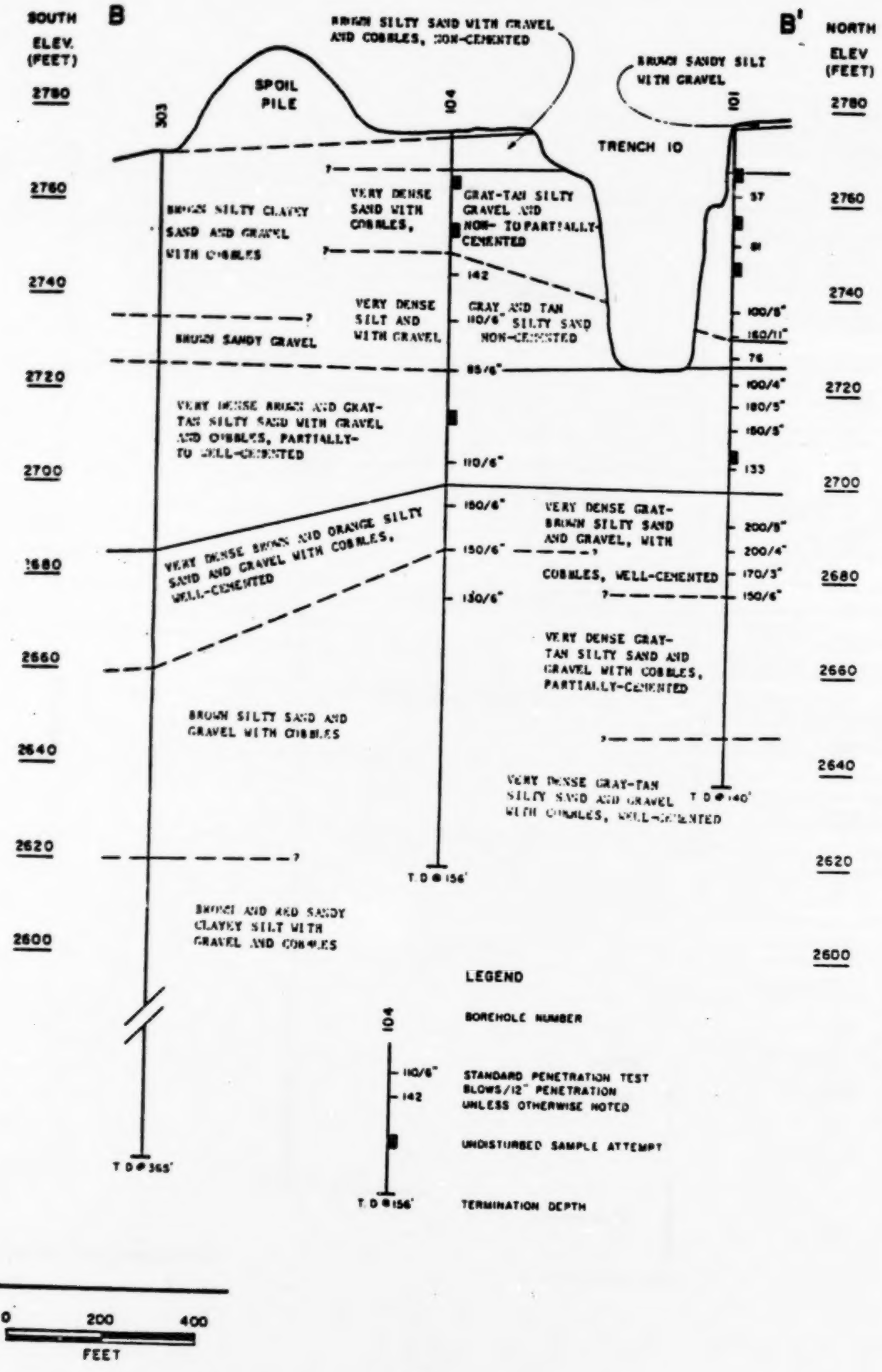

SOUTH
B
ELEV. (FEET)
B'
NORTH
ELEV (FEET)
2780
2760
2740
2720
2700
2680
2660
2640
2620
2600
SPOIL PILE
303
104
101
BROWN SILTY SAND WITH GRAVEL AND COBBLES, NON-CEMENTED
BROWN SANDY SILT WITH GRAVEL
TRENCH 10
BROWN SILTY CLAYEY SAND AND GRAVEL WITH COBBLES
VERY DENSE SAND WITH COBBLES,
GRAY-TAN SILTY GRAVEL AND NON- TO PARTIALLY-CEMENTED
VERY DENSE SILT AND WITH GRAVEL
GRAY AND TAN SILTY SAND NON-CEMENTED
BROWN SANDY GRAVEL
VERY DENSE BROWN AND GRAY-TAN SILTY SAND WITH GRAVEL AND COBBLES, PARTIALLY- TO WELL-CEMENTED
VERY DENSE BROWN AND ORANGE SILTY SAND AND GRAVEL WITH COBBLES, WELL-CEMENTED
VERY DENSE GRAY-BROWN SILTY SAND AND GRAVEL, WITH COBBLES, WELL-CEMENTED
VERY DENSE GRAY-TAN SILTY SAND AND GRAVEL WITH COBBLES, PARTIALLY-CEMENTED
BROWN SILTY SAND AND GRAVEL WITH COBBLES
VERY DENSE GRAY-TAN SILTY SAND AND GRAVEL WITH COBBLES, WELL-CEMENTED
BROWN AND RED SANDY CLAYEY SILT WITH GRAVEL AND COBBLES
?
142
110/6"
85/6"
110/6"
180/6"
150/6"
130/6"
37
81
100/8"
160/11"
76
100/4"
180/5"
180/5"
133
200/5"
200/4"
170/3"
150/6"
T.D @ 365'
T.D @ 156'
T.D @ 140'
LEGEND
104 BOREHOLE NUMBER
110/6" 142 STANDARD PENETRATION TEST BLOWS/12" PENETRATION UNLESS OTHERWISE NOTED
UNDISTURBED SAMPLE ATTEMPT
T.D @ 156' TERMINATION DEPTH
0
200
400
FEET

FIGURE 4.3-5

CASE STUDY C CROSS SECTION C-C'

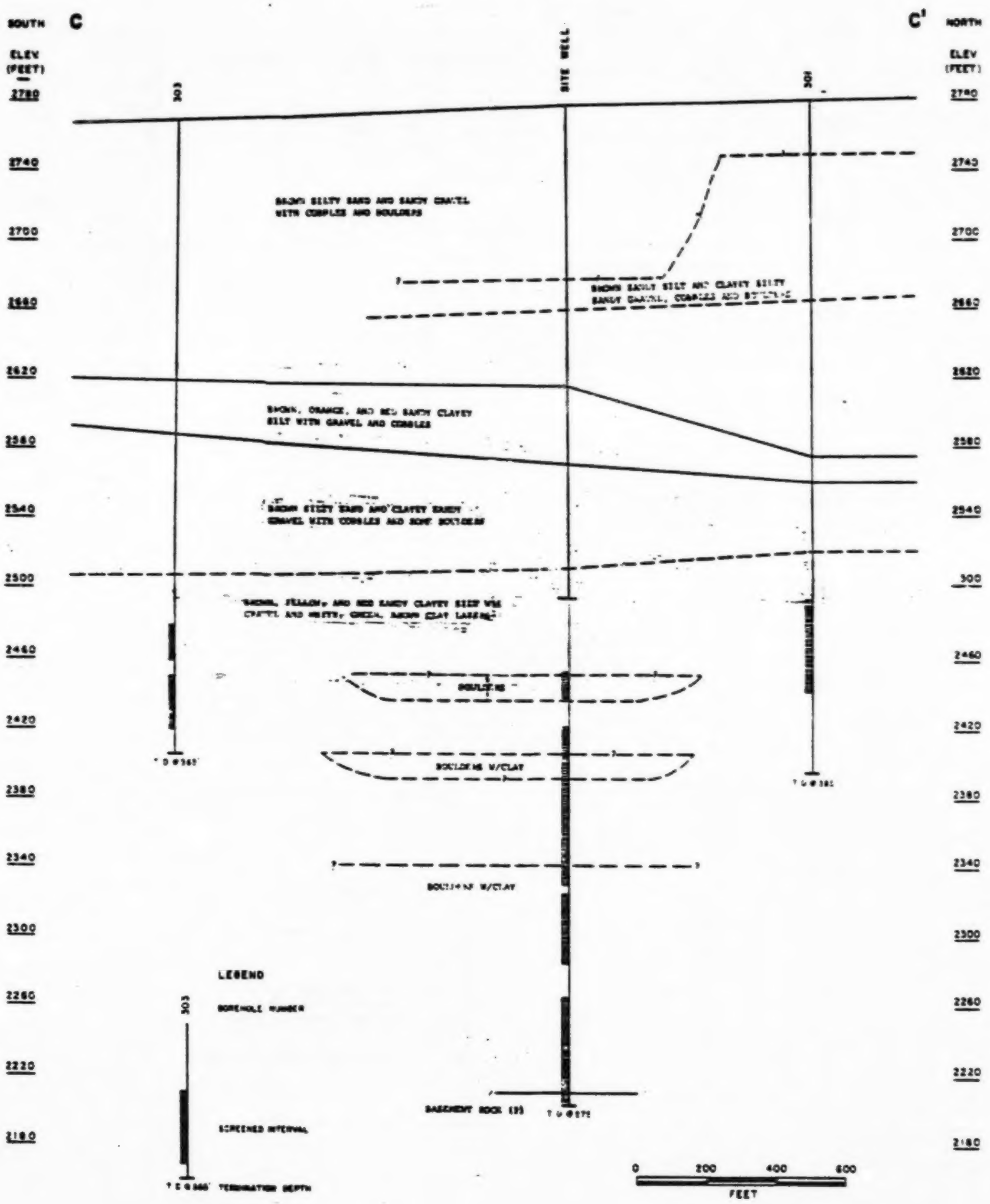
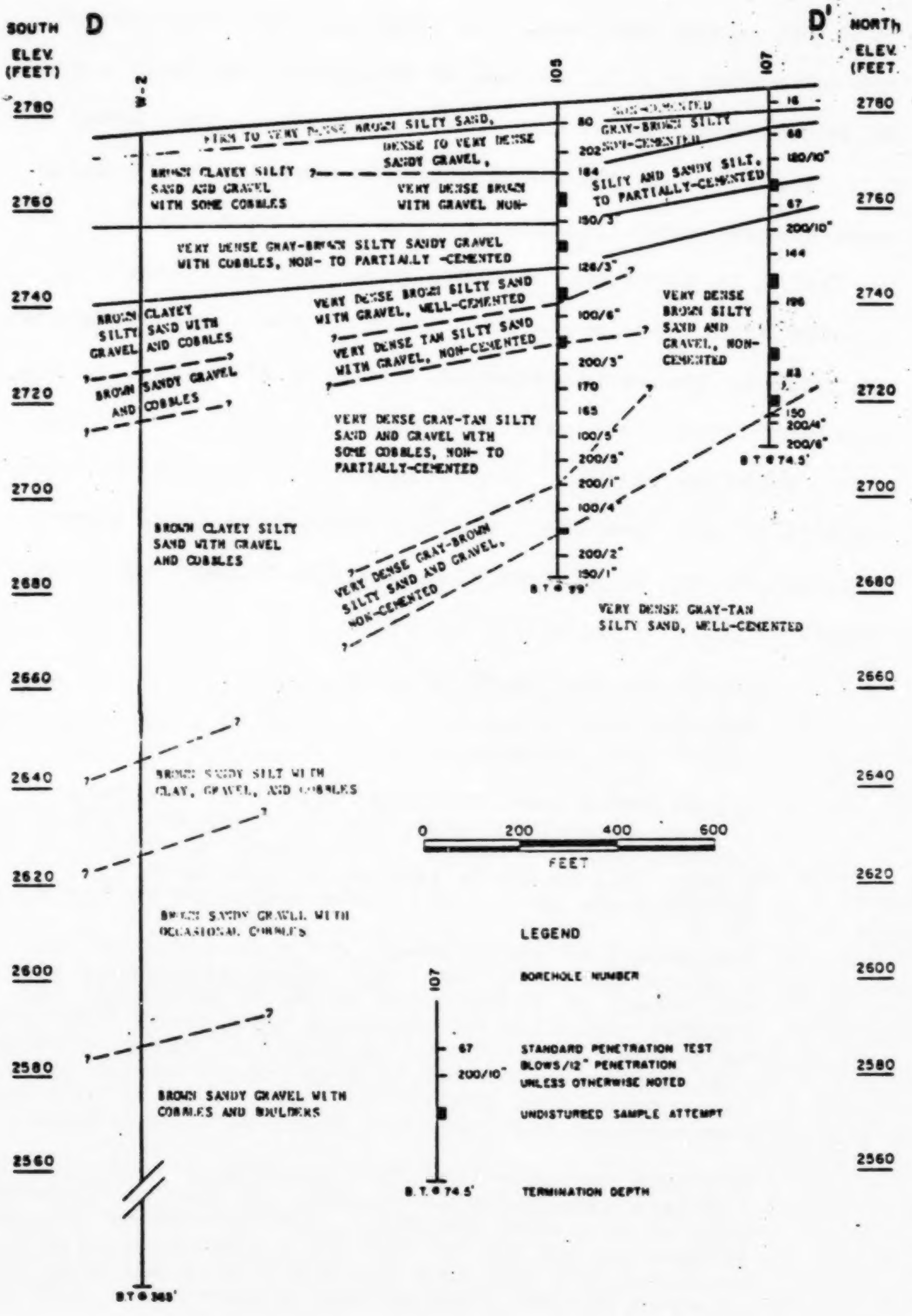

SOUTH
C
ELEV (FEET)
C'
NORTH
ELEV (FEET)
2780
2740
2700
2660
2620
2580
2540
2500
2460
2420
2380
2340
2300
2260
2220
2180
303
SITE WELL
301
BROWN SILTY SAND AND SANDY GRAVEL WITH COBBLES AND BOULDERS
BROWN SANDY SILT AND CLAYEY SILTY SANDY GRAVEL, COBBLES AND BOULDERS
BROWN, ORANGE, AND RED SANDY CLAYEY SILT WITH GRAVEL AND COBBLES
BROWN SILTY SAND AND CLAYEY SANDY GRAVEL WITH COBBLES AND SOME BOULDERS
BROWN, YELLOW, AND RED SANDY CLAYEY SILT WITH GRAVEL AND WHITE, GREEN, BROWN CLAY LAYERS
BOULDERS
BOULDERS W/CLAY
BOULDERS W/CLAY
?
BASEMENT ROCK (?)
T D @ 362'
T D @ 381'
T D @ 575'
LEGEND
303
BOREHOLE NUMBER
SCREENED INTERVAL
T D @ 360' TERMINATION DEPTH
0
200
400
600
FEET

FIGURE 4.3-6

CASE STUDY C CROSS SECTION D-D'


SOUTH
D
ELEV. (FEET)
D'
NORTH
ELEV. (FEET)
W-2
105
107
2780
2760
2740
2720
2700
2680
2660
2640
2620
2600
2580
2560
FIRM TO VERY DENSE BROWN SILTY SAND,
DENSE TO VERY DENSE SANDY GRAVEL,
BROWN CLAYEY SILTY SAND AND GRAVEL WITH SOME COBBLES
VERY DENSE BROWN WITH GRAVEL NON-
NON-CEMENTED
GRAY-BROWN SILTY
NON-CEMENTED
SILTY AND SANDY SILT, TO PARTIALLY-CEMENTED
VERY DENSE GRAY-BROWN SILTY SANDY GRAVEL WITH COBBLES, NON- TO PARTIALLY -CEMENTED
BROWN CLAYEY SILTY SAND WITH GRAVEL AND COBBLES
VERY DENSE BROWN SILTY SAND WITH GRAVEL, WELL-CEMENTED
VERY DENSE TAN SILTY SAND WITH GRAVEL, NON-CEMENTED
VERY DENSE BROWN SILTY SAND AND GRAVEL, NON-CEMENTED
BROWN SANDY GRAVEL AND COBBLES
VERY DENSE GRAY-TAN SILTY SAND AND GRAVEL WITH SOME COBBLES, NON- TO PARTIALLY-CEMENTED
BROWN CLAYEY SILTY SAND WITH GRAVEL AND COBBLES
VERY DENSE GRAY-BROWN SILTY SAND AND GRAVEL, NON-CEMENTED
VERY DENSE GRAY-TAN SILTY SAND, WELL-CEMENTED
BROWN SANDY SILT WITH CLAY, GRAVEL, AND COBBLES
BROWN SANDY GRAVEL WITH OCCASIONAL COBBLES
BROWN SANDY GRAVEL WITH COBBLES AND BOULDERS
80
202
184
150/3"
126/3"
100/6"
200/3"
170
165
100/5"
200/5"
200/1"
100/4"
200/2"
150/1"
B.T. @ 99'
16
68
180/10"
67
200/10"
144
196
83
150
200/4"
200/6"
B.T. @ 74.5'
B.T. @ 365'
?
0
200
400
600
FEET
LEGEND
107
BOREHOLE NUMBER
67
200/10"
STANDARD PENETRATION TEST BLOWS/12" PENETRATION UNLESS OTHERWISE NOTED
UNDISTURBED SAMPLE ATTEMPT
B.T. @ 74.5'
TERMINATION DEPTH

The total amount of recharge was 1.5 inches or an average of 0.025 inches per year. As noted earlier, recharge of the uppermost aquifer occurs in relatively confined areas of stream channels as mountain streams reach the foothills.

The evidence presented strongly suggests that, based upon minimal precipitation, ground-water recharge will be minimal. In addition, leachate generated as a result of precipitation should also be minimal. The moisture balance may also be inadequate however, since in arid areas of the southwest, most precipitation events are high intensity, short duration storms. Therefore performing a monthly water balance is not accurate. A daily water balance is more appropriate and at present the site owner/ operator is performing these calculations.

4.3.1 Summary of Locational Evaluation

- The facility is not within protected lands or a high hazard and unstable terrain.
- All evidence presented indicates that the facility is located in an arid environment characterized by large minimal recharge areas and limited recharge/discharge areas. All evidence indicates that units at the facility are positioned above a minimal recharge area.
- The effect of evapotranspiration on infiltration needs to be clarified. At present it appears that the effect of evaporation is only significant for liquids that have not migrated more than a few feet below the land surface. Although it could be argued that transpiration due to deep-rooted desert plants may remove water that infiltrates, these plants have been removed and take many years to re-establish.
- Although the potential for groundwater recharge and leachate generation is minimal, it must be stressed that at this site the precipitation-induced leachate generation was not as much of a concern as potential leachate from old (but post-RCRA) disposal practices in which drummed liquids were disposed of. Also,

numerous old wells are located at the site; even the thick unsaturated zone cannot preclude contaminant migration down the well casings.

- The discussion of the location of the site only considered precipitation induced leachate generation in the natural setting. Therefore the statement concerning the low potential for leachate migration is not appropriate since the site has disposed of bulk liquids and has disturbed the natural environment. The potential for leachate migration (leachate from all sources) has not been adequately addressed.
- The possibility of lateral movement above the groundwater surface, past the point of compliance, is a concern at this and other sites with similar hydrogeologic settings.

4.3.2 Discussion of Location Issues

The locational evaluation indicated that this facility is located in a zone having a low potential for recharge. Leachate escaping a unit is not likely to reach the uppermost aquifer or migrate horizontally to any extent. Verification of minimal recharge occurring at this setting will require a simulation of the unsaturated flow regime calibrated using site-specific information. Additional site investigation will be required to determine the extent of lateral movement of contaminants from pre-RCRA activities.

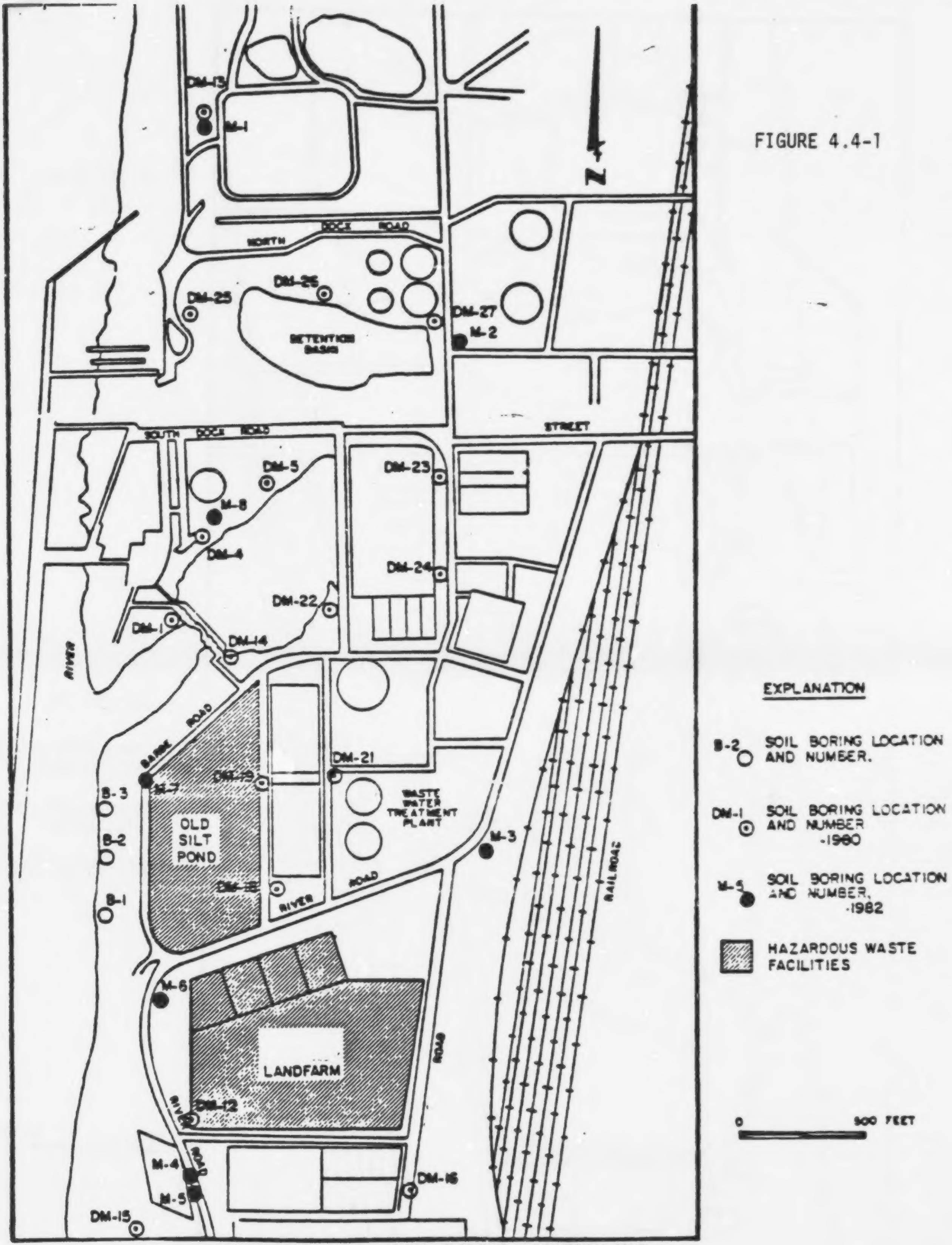
4.4 CASE STUDY D

Location:	Southeastern United States
Type of Unit:	Surface impoundment, land treatment
Physiographic Province:	Gulf Coastal Plain

This facility is at a refinery that has operated since the late 1930s. Two regulated units are used to store and dispose API separator sludge. Both the surface impoundment and the land treatment area are located approximately 250 feet east of a major river. Approximately 13 acres are used for the land treatment area and a slightly smaller area is used for the surface impoundment. A review of monitoring data collected over a period of one year indicates the presence of arsenic in downgradient wells, selenium in all wells, ammonia in downgradient wells, and barium, cadmium, and lead in isolated samples. High levels of TOC were detected in all wells but appeared higher in downgradient wells. Although no review of the statistical analysis of the data was performed, the use of a contaminated upgradient well as a background well is questionable.

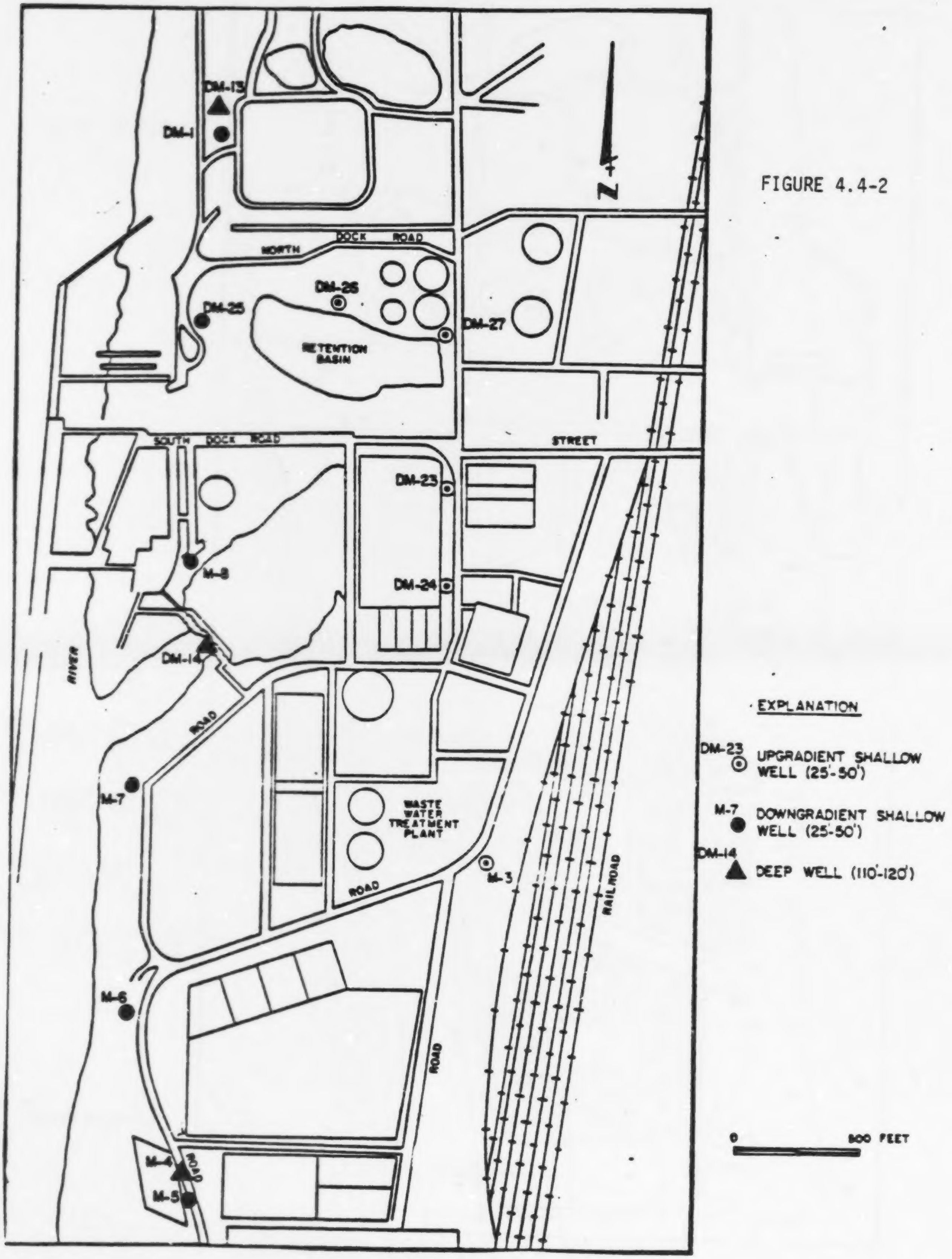
Most of the waste management area is situated on loosely consolidated floodplain deposits consisting primarily of unconsolidated clays, with some lenses of silt and sand. These sediments were deposited in the incised erosional channel of the river. The upper surface of the waste treatment area is covered with five feet to more than 30 feet of rubble and fill materials. The natural soil below the fill is a 10 to 30 foot thick clay layer underlain by 10 to 60 feet of loosely consolidated, tan and gray silty clay to sandy clayey silts, interbedded with relatively thin lenses of clay, silt, and sand of limited lateral extent. Near the river, the silt/clay unit is underlain by a very permeable sand and gravel layer more than 30 feet thick. The total thickness of the alluvial deposits at the site is not known (see the site plan and geologic cross-sections in Figures 4.4-1 through 4.4-8).

FIGURE 4.4-1


N
DM-13
M-1
NORTH DOCK ROAD
DM-26
DM-25
DM-27
M-2
DETENTION BASIN
SOUTH DOCK ROAD
STREET
DM-5
M-8
DM-4
DM-23
DM-24
DM-22
DM-1
DM-14
RIVER
BARGE ROAD
DM-21
M-7
DM-19
B-3
B-2
B-1
OLD SILT POND
WASTE WATER TREATMENT PLANT
M-3
DM-18
RIVER ROAD
RAILROAD
M-6
LANDFARM
ROAD
RIVER ROAD
DM-12
M-4
M-5
DM-16
DM-15
EXPLANATION
B-2 ○ SOIL BORING LOCATION AND NUMBER.
DM-1 ⊙ SOIL BORING LOCATION AND NUMBER -1980
M-5 ● SOIL BORING LOCATION AND NUMBER, -1982
▨ HAZARDOUS WASTE FACILITIES
0
900 FEET

CASE STUDY D: SOIL BORING LOCATION MAP

FIGURE 4.4-2


DM-13
DM-1
N
NORTH DOCK ROAD
DM-26
DM-25
DM-27
RETENTION BASIN
SOUTH DOCK ROAD
STREET
DM-23
M-8
DM-24
DM-14
RIVER
ROAD
M-7
WASTE WATER TREATMENT PLANT
M-3
RAILROAD
ROAD
M-6
ROAD
M-4
M-5
ROAD
EXPLANATION
DM-23 ◎ UPGRADIENT SHALLOW WELL (25'-50')
M-7 ● DOWNGRADIENT SHALLOW WELL (25'-50')
DM-14 ▲ DEEP WELL (110'-120')
0
800 FEET

"D" CASE STUDY MONITORING-WELL NETWORK

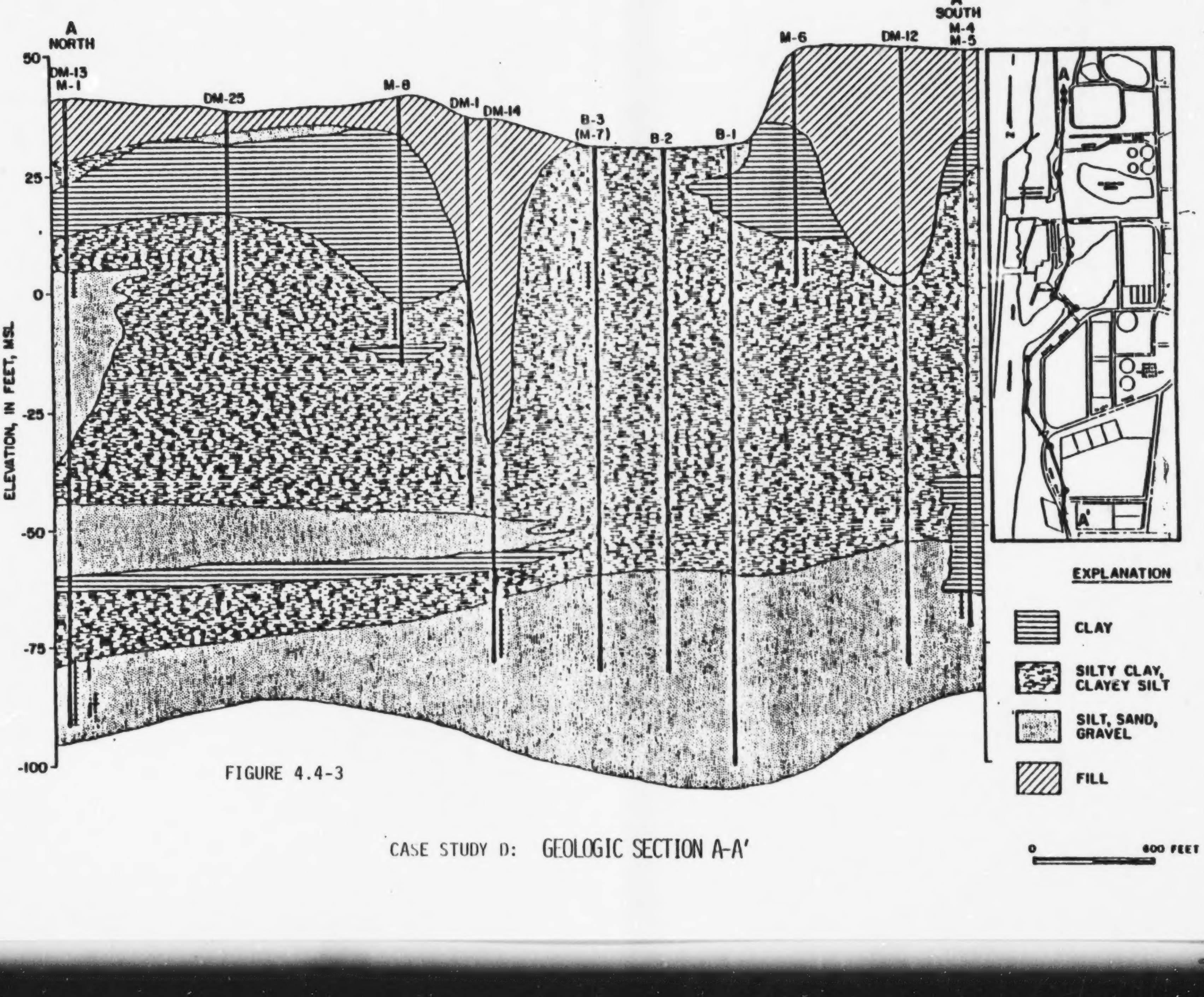

A
NORTH
A'
SOUTH
DM-13
M-1
DM-25
M-8
DM-1
DM-14
B-3
(M-7)
B-2
B-1
M-6
DM-12
M-4
M-5
50
25
0
-25
-50
-75
-100
ELEVATION, IN FEET, MSL
A
A'
N
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
600 FEET

FIGURE 4.4-3

CASE STUDY D: GEOLOGIC SECTION A-A'

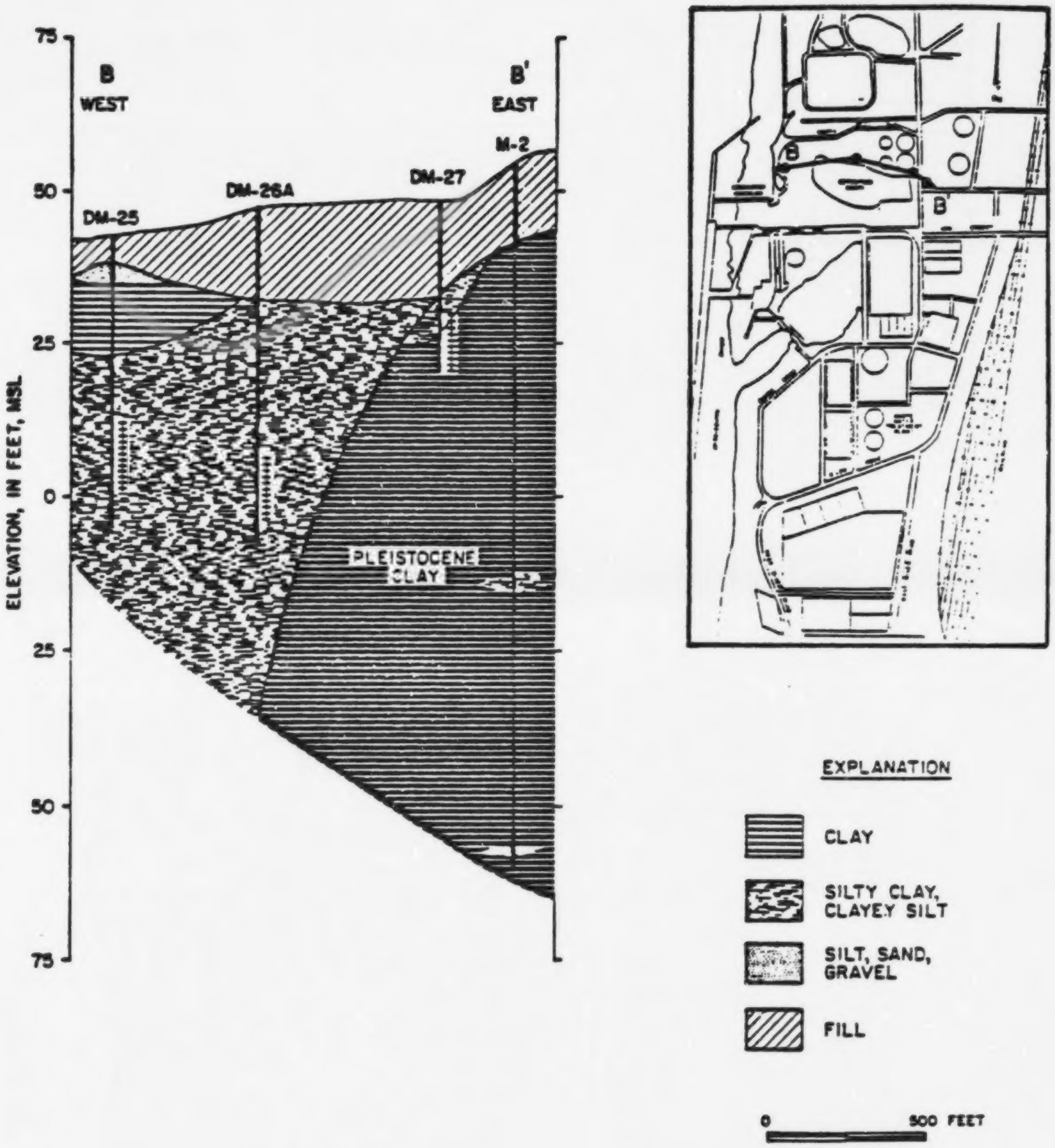

75
50
25
0
25
50
75
ELEVATION, IN FEET, MSL
B
WEST
B'
EAST
M-2
DM-27
DM-26A
DM-25
PLEISTOCENE CLAY
B
B'
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
500 FEET

FIGURE 4.4-4

CASE STUDY D: GEOLOGIC SECTION B-B'

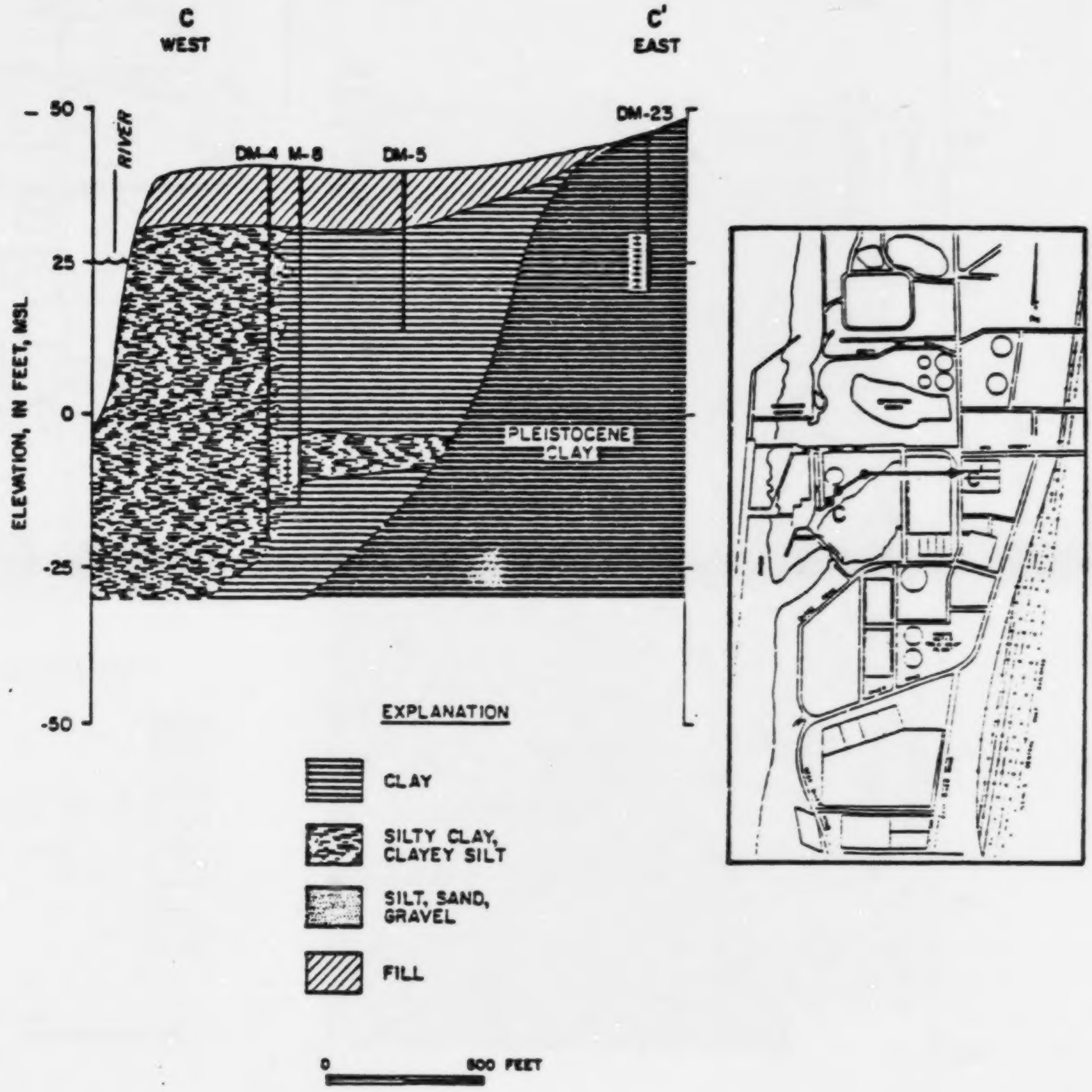

C
WEST
C'
EAST
50
25
0
-25
-50
ELEVATION, IN FEET, MSL
RIVER
DM-4
M-8
DM-5
DM-23
PLEISTOCENE CLAY
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
800 FEET
C
C'

FIGURE 4.4-5

CASE STUDY D: GEOLOGIC SECTION C-C'

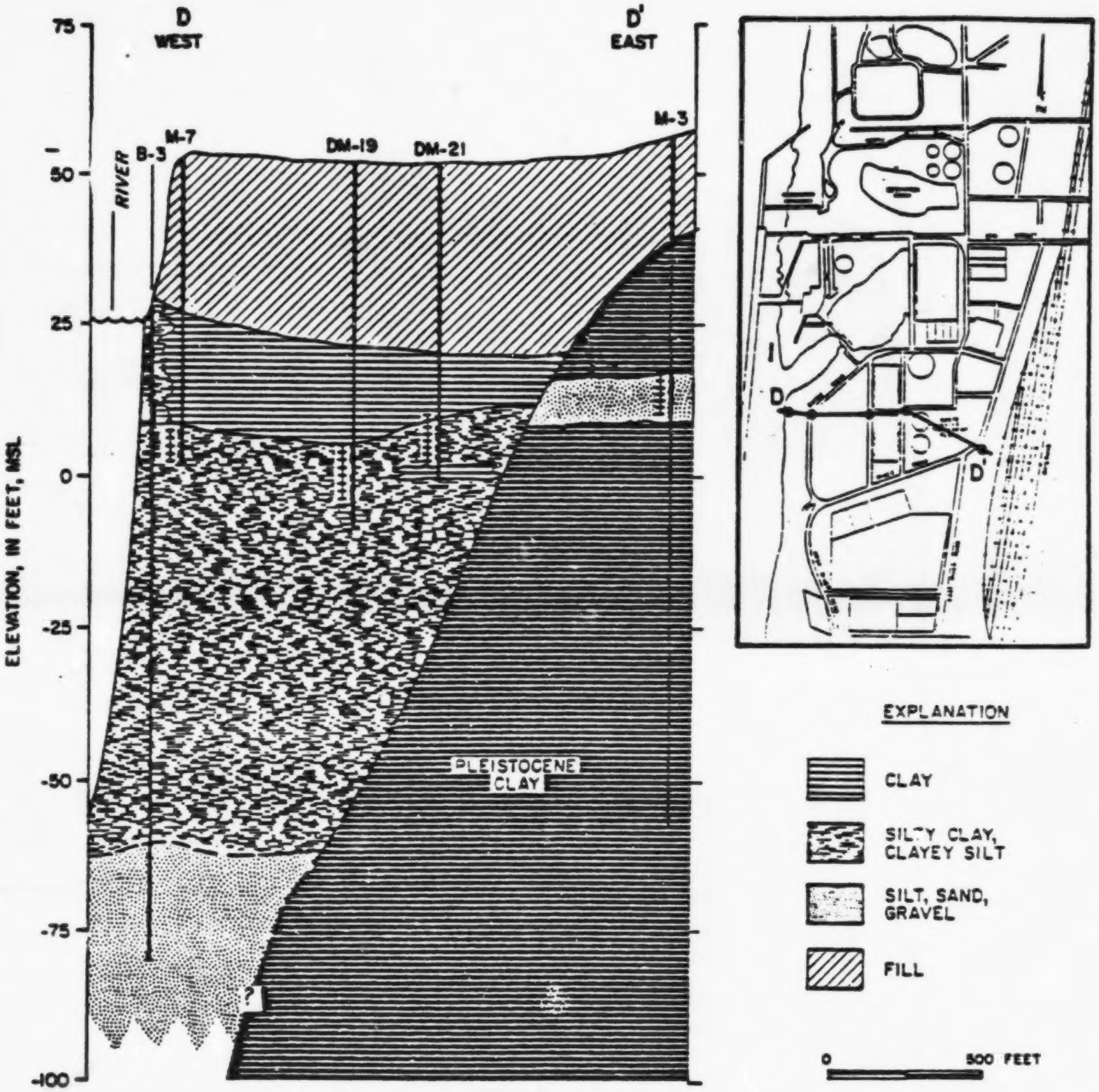

D
WEST
D'
EAST
75
50
25
0
-25
-50
-75
-100
ELEVATION, IN FEET, MSL
RIVER
B-3
M-7
DM-19
DM-21
M-3
PLEISTOCENE CLAY
?
D
D'
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
500 FEET

FIGURE 4.4-6

CASE STUDY D GEOLOGIC SECTION D-D'

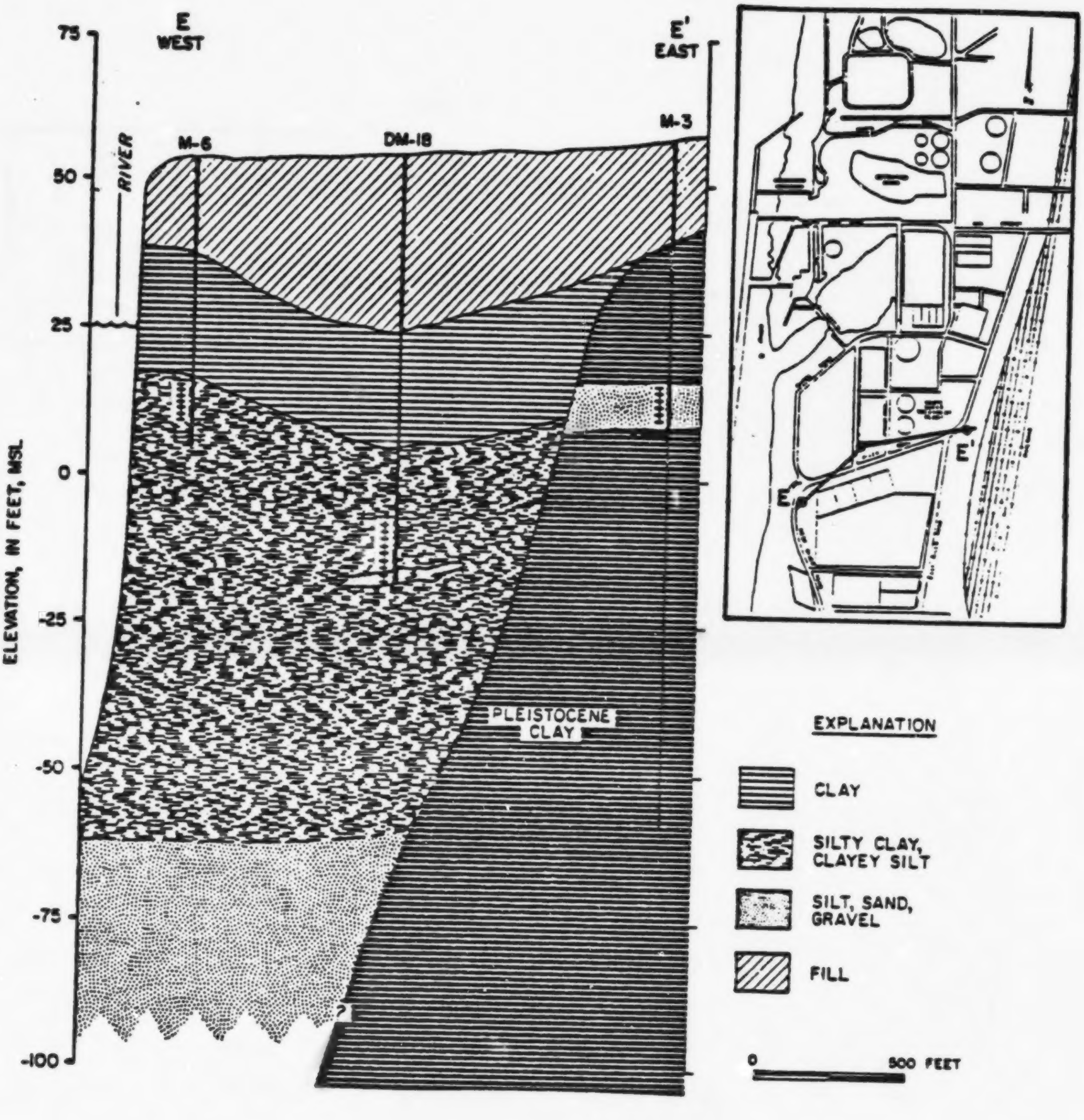

E
WEST
E'
EAST
75
50
25
0
-25
-50
-75
-100
RIVER
M-6
DM-18
M-3
ELEVATION, IN FEET, MSL
PLEISTOCENE CLAY
?
E
E'
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
500 FEET

FIGURE 4.4-7

CASE STUDY D: GEOLOGIC SECTION E-E'

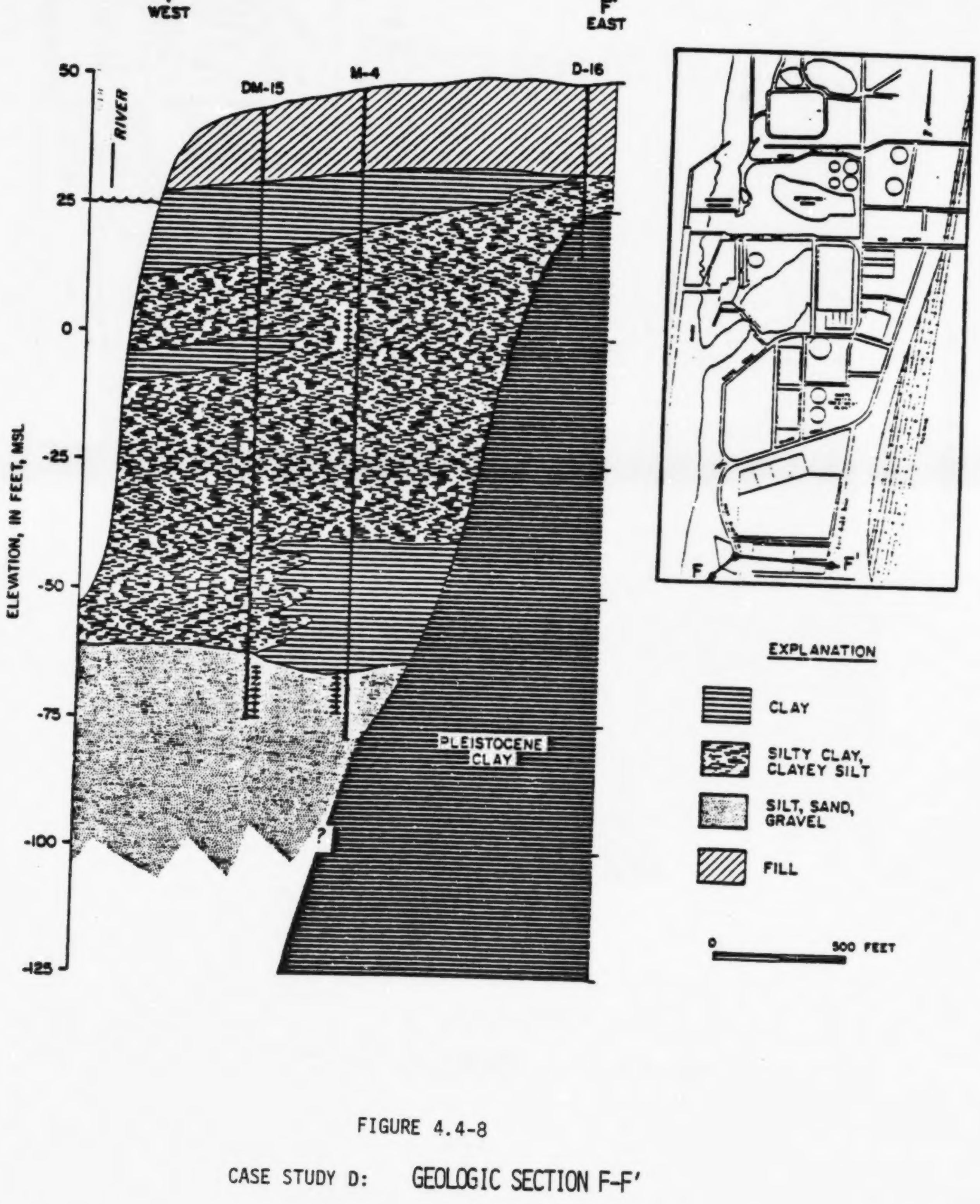

F
WEST
F'
EAST
50
25
0
-25
-50
-75
-100
-125
ELEVATION, IN FEET, MSL
RIVER
DM-15
M-4
D-16
PLEISTOCENE CLAY
?
F
F'
EXPLANATION
CLAY
SILTY CLAY, CLAYEY SILT
SILT, SAND, GRAVEL
FILL
0
500 FEET

FIGURE 4.4-8

CASE STUDY D: GEOLOGIC SECTION F-F'

The upper alluvial materials contain a water table that is hydraulically connected to the river by an underlying aquifer. Some seasonal change in gradients is expected but no flow reversals have been demonstrated. Permeabilities ranged between 10^{-3} and 10^{-6} cm/sec based on field testing. The steepest horizontal gradient was 0.017 and a vertical gradient as steep as 0.2 was estimated.

4.4.1 Summary of Locational Evaluation

- The facility is not within protected lands or a high hazard and unstable terrain.
- The uppermost aquifer is not identified. Most production wells in the area are located over 300 feet deep in sandy aquifers. Hydraulic conductivity and gradient information is incomplete.
- Two principle ground-water flow pathways can be identified for potential contaminant migration. One is horizontally west toward the river. The other is vertical toward the lower sandy aquifers. The role of the fill material and the underlying sand and gravel aquifer in ground-water flow has not been studied thoroughly.
- The flow regime appears to be relatively uncomplicated and proper monitoring should be feasible at the site.
- The major river system is directly downgradient.
- The facility is located over aquifers which are used for the water supply of a medium-sized city. Contamination of this aquifer has not been ruled out by the above analysis.

4.4.2 Discussion of Location Issues

Based on the information available, it was determined that this site fits into the category of unacceptable locations principally due to inadequate site characterization and failure to meet the site monitoring criterion since a well network designed for proper ground-water monitoring has not been thoroughly designed.

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5.0 FUTURE AGENCY EFFORTS

The Location Guidance and Regulatory Program Under 40 CFR Part 264

The Agency recognizes the need for comprehensive hydrogeologic standards to supplement existing land disposal facility design, operation, and ground-water protection standards. As a first step in developing a location program, the Office of Solid Waste and Emergency Response will issue a series of guidance manuals in phases for use by RCRA land disposal facility permit writers as well as owner/operators. These manuals will be designed to assist the reader in evaluating hydrogeologic conditions that exist at a particular facility location.

This manual (Phase I) identifies five criteria for location acceptability that, if not met, may warrant permit denial under the present Part 264 permitting standards and other Federal statutes and regulations. A second RCRA guidance (Phase II) will supplement the Agency's Ground-Water Protection Strategy and will reference guidance pursuant to the Strategy. An important factor in the implementation of this Strategy will be the definition of ground-water "vulnerability." The Agency's response to facility location over several classes of ground water and usage classifications will depend upon whether or not the facility is in a vulnerable hydrogeologic setting that can lead to contamination of the ground water. The guidance will present a definition of site acceptability based upon how vulnerable the usable ground water is to contamination. In addition, the manual will provide permit writers with step-by-step means of evaluating whether or not various criteria for an acceptable site are met and technical methods for analyzing hydrologic and geologic factors including subsurface flow conditions and contaminant time of travel. Technical methods will be calibrated and tested using actual RCRA facility location data and other sources, and risk assessment techniques. Locational issues discussed in the Phase I manual will be highlighted in a series of Phase II appendices that will illustrate the use of various graphic and simulation techniques for evaluating location.

In addition to the guidance manuals described above, the Agency has begun a longer-term program to revise current RCRA standards to incorporate hydrogeologic and other locational concerns. Hydrogeologic criteria are needed to help provide long-term protection of public health and the environment. A 1983 EPA study (Liner/Location Study by Ertec Atlantic, Inc.) concluded that proper site selection and appropriate hydrologic and geologic conditions are important factors in maintaining long-term protection of the environment. The recent RCRA Hazardous and Solid Waste Amendments (HSWA) of 1984 contain specific amendments that require the Agency to promulgate location regulations for new and existing RCRA facilities. In addition, the Agency's Ground-Water Protection Strategy directs the need for location regulations based on ground-water classification and vulnerability.

The following table describes the major milestones of the program:

Table 5.0-1: PROGRAM MILESTONE FOR RCRA LOCATION GUIDANCE AND REGULATIONS

Program Milestone	Completion
1. Background Support Document - Review of State Siting Criteria	January 84 (Revised September 84)
2. Issue Technical Guidance	
A. Permit Writers' Guidance Manual for the Location of Hazardous Waste Treatment, Storage, and Disposal Facilities	
Phase I: Criteria for Location Acceptability and Existing Applicable Regulations	November 84 (Final Draft February 85)
- Explains use of existing applicable RCRA regulations and other Federal statutes	
Phase II: Criteria for Evaluating a Vulnerable Hydrogeology	October 85 (in progress)
- Incorporates the GWP Strategy and references classification guidance - Defines a vulnerable hydrogeology based on ground-water flow analyses - Provides detailed methods for site analysis	
Location Case Studies and Phase II Appendices	October 85 (in progress)
- Phase II technical methods; definition of vulnerability tested and calibrated using actual RCRA facility location data and other sources	
B. Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment Units	(in progress)
3. Regional Training Programs for Permit Writers - Phases I and II Guidance Manuals	FY 86
4. Begin Development of Proposed Hydrogeologic-Based Location Standards Under 40 CFR Part 264	FY 86
5. Propose Hydrogeologic-Based Location Standards Under 40 CFR Part 264	FY 87
6. Promulgate Final Hydrogeologic-Based Location Standards Under 40 CFR Part 264	
7. Regional Training Programs for Permit Writers - Location Standards Under 40 CFR Part 264	

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